LAT Instrument Science Operations Center

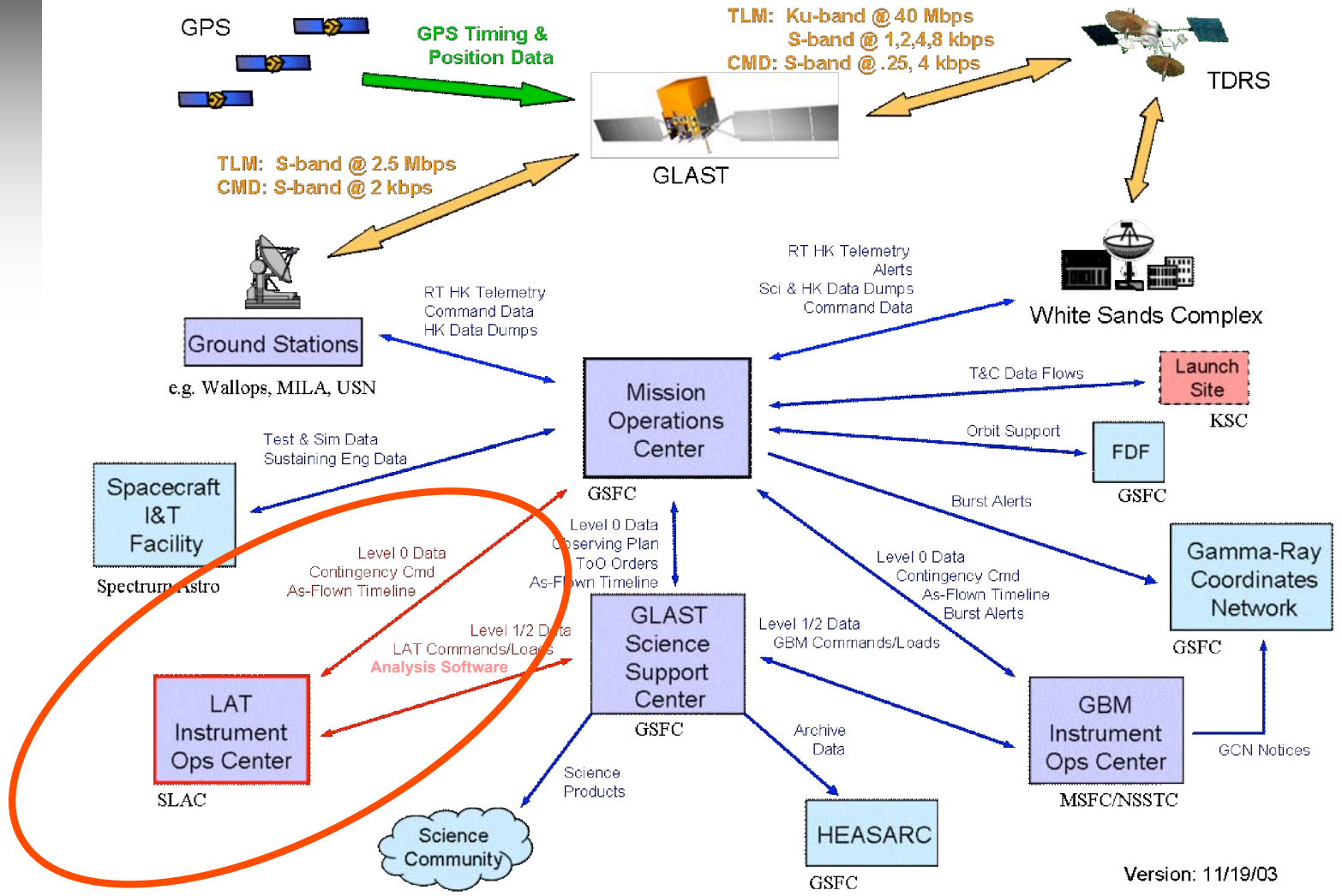
GS SDR Section 15

Bill Craig/Jim Martin/Lori Bator/Steve Culp

Outline

- ***Objectives & Overview, Pipeline***
  - *(Craig) 25 minutes*
- ***Requirements***
  - *(Martin) 10 minutes*
- ***Command, Health and Safety, Ops Scenarios***
  - *(Bator) 20 minutes*
- ***Tools and Architecture***
  - *(Culp) 20 minutes*
- ***Management, Cost, Schedule and Risks***
  - *(Craig) 15 minutes*

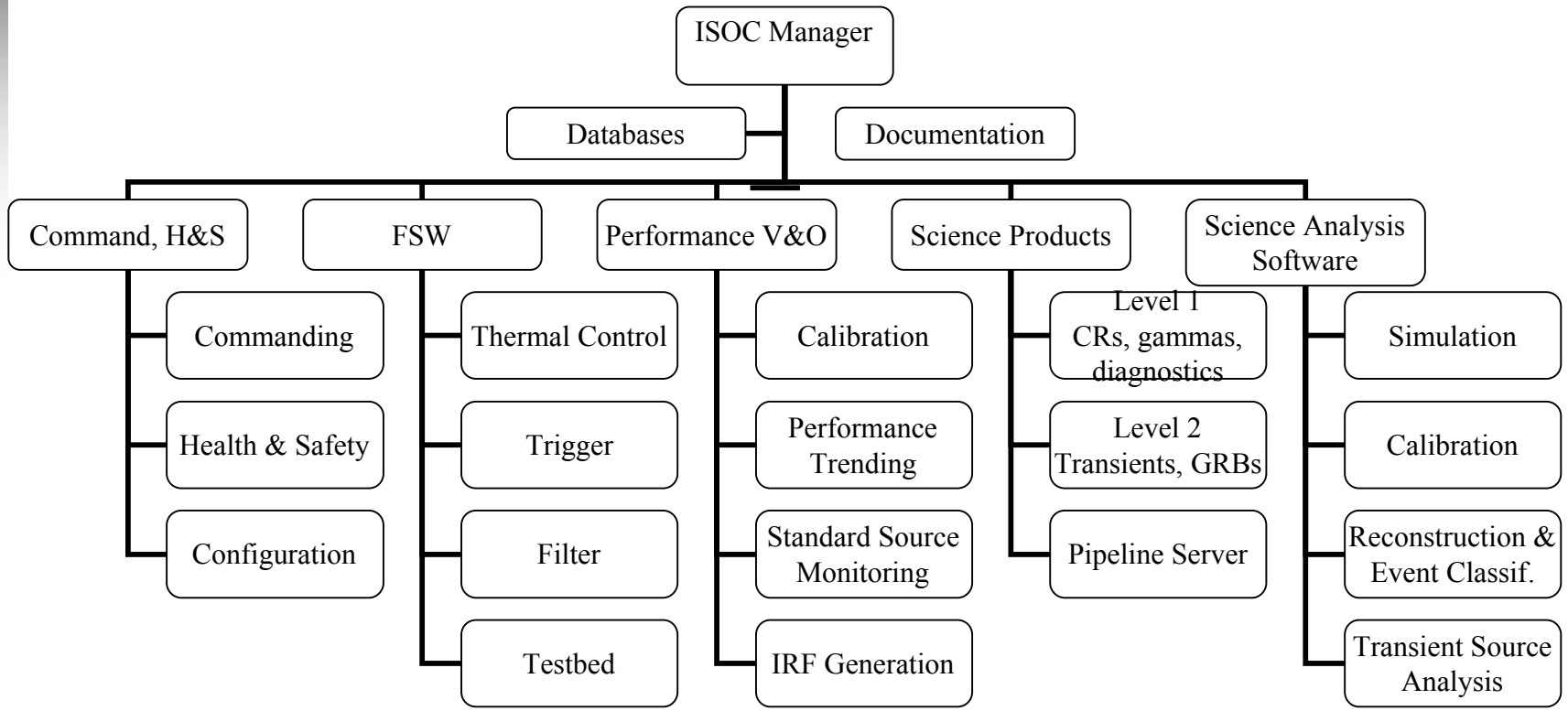
LAT ISOC's Role in the GLAST GDS



Objectives

- ***The LAT ISOC is organized to:***
  - *safely operate the instrument and*
  - *produce the LAT's science data products*
- ***Functions:***
  - *Maintain and modify FSW and Testbed*
  - *Command generation, health and safety monitoring*
  - *Performance verification and optimization*
  - *Process and archive Level 1 and Level 2 data*
  - *Develop and optimize the software pipeline that produces the higher level products*
- ***These functions are organized as teams that share personnel***

ISOC Functional Organization

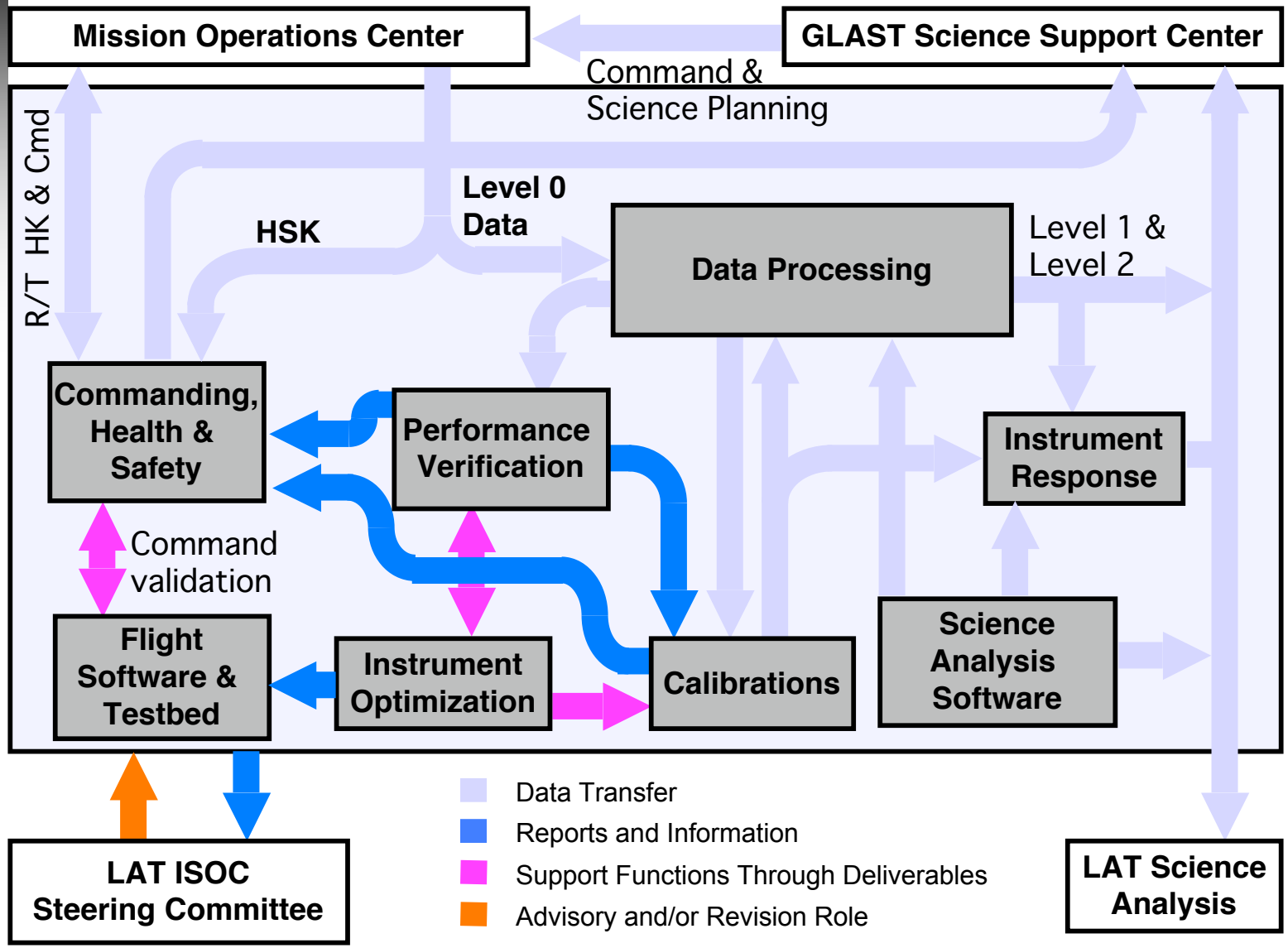


ISOC REVIEWS and RFA STATUS

Reviews	Date
LAT CDR	12-16 May 2003
ISOC Peer Review	2 March 2004
ISOC CDR	4 Aug 2004

No.	RFA Summary	Requestor	Actionee	Status
1	ISOC Documentation Tree	E. Andrews	L. Bator	Submitted
2	Requirements Traceability Tool	E. Andrews	J. Martin	Plan submitted
3	Add ISOC Architecture Diagram	E. Andrews	B. Craig	Submitted
4	ISOC Requirements and Testing	E. Andrews	J. Martin	ECD 10/1/04
5	SAA Handling Approach	E. Andrews	L. Bator	ECD 8/31/04
6	Launch Critical Support Plan	M. Rackley J. Leibee	S. Culp	ECD 8/27/04
7	Red/Yellow Limit Philosophy	J. Leibee	L. Bator	ECD 8/27/04
8	SAS Verification Approach	M. Rackley	B. Craig J. Martin	Submitted

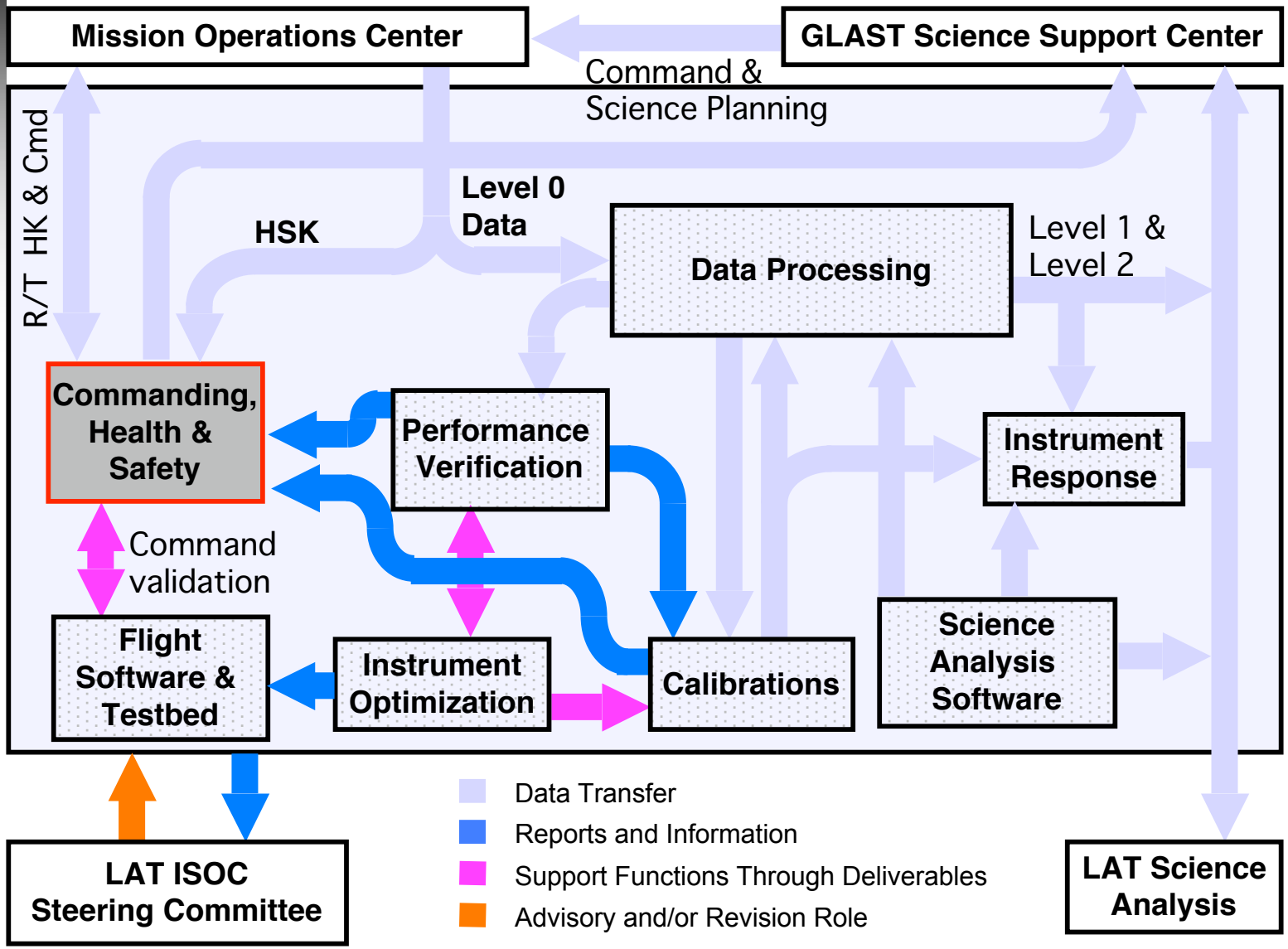
LAT ISOC Architecture



Commanding, Health and Safety

- ***The Commanding, Health and Safety (CHS) team is responsible for:***
  - *generation and validation of commands and command sequences,*
  - *passing commands on to the GSSC,*
  - *verifying these commands were executed,*
  - *receiving Level 0 data from the MOC,*
  - *logging and archiving of all commands and Level 0 data,*
  - *monitoring that data to ascertain and track the health and safety of the instrument,*
  - *continuous knowledge of the configuration of the LAT.*

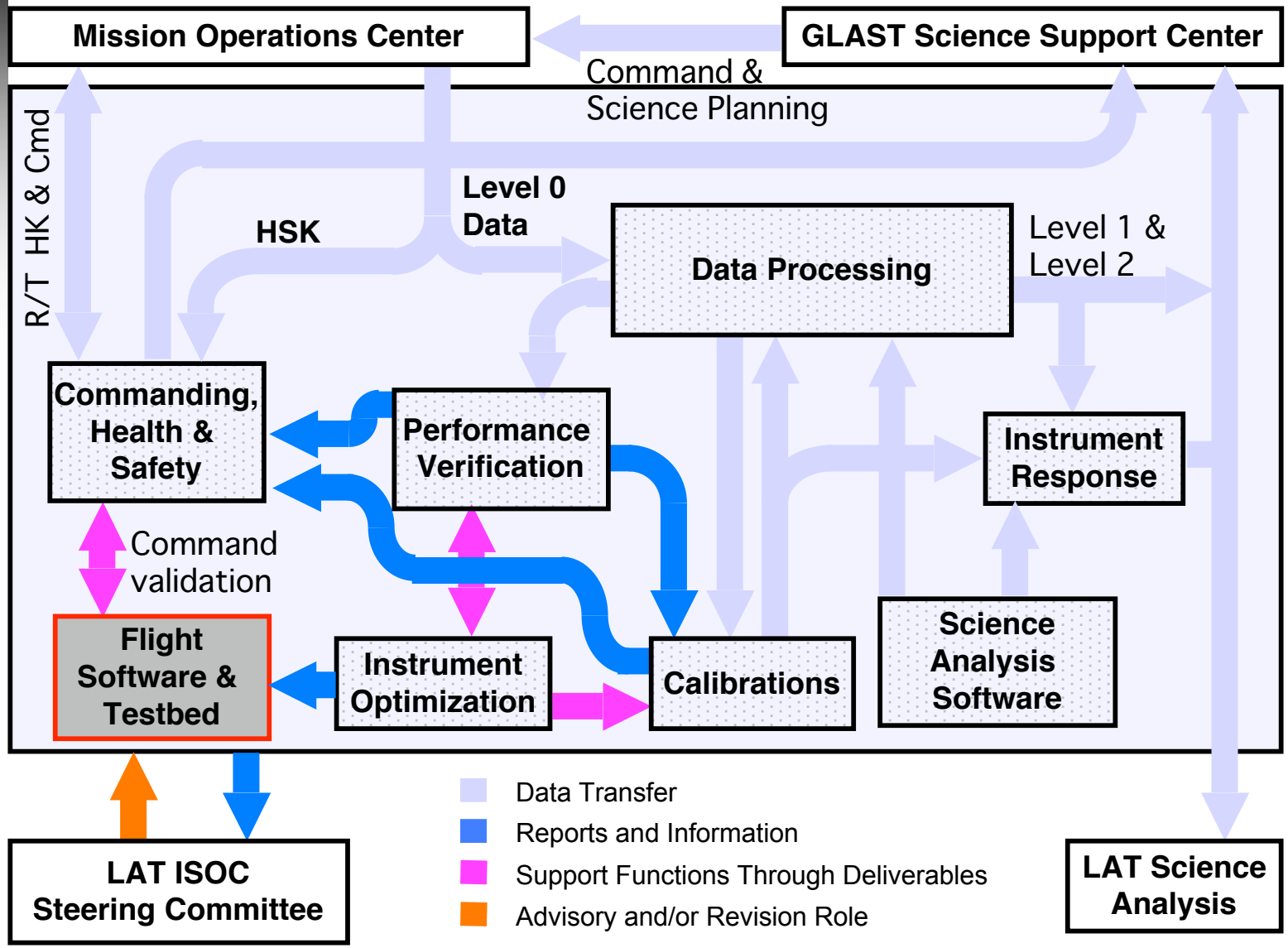
CHS in the ISOC Architecture



Flight Software

- ***The Flight Software (FSW) team is responsible for:***
  - *Updating and validation of all flight software files,*
  - *Debug or problem fixes to the FSW,*
  - *Implementation, and validation on the instrument test bed of authorized upgrades to FSW,*
  - *Continuing maintenance of the instrument test bed to ensure it is available to validate code and command sequences as well as to investigate any anomalies seen on orbit*

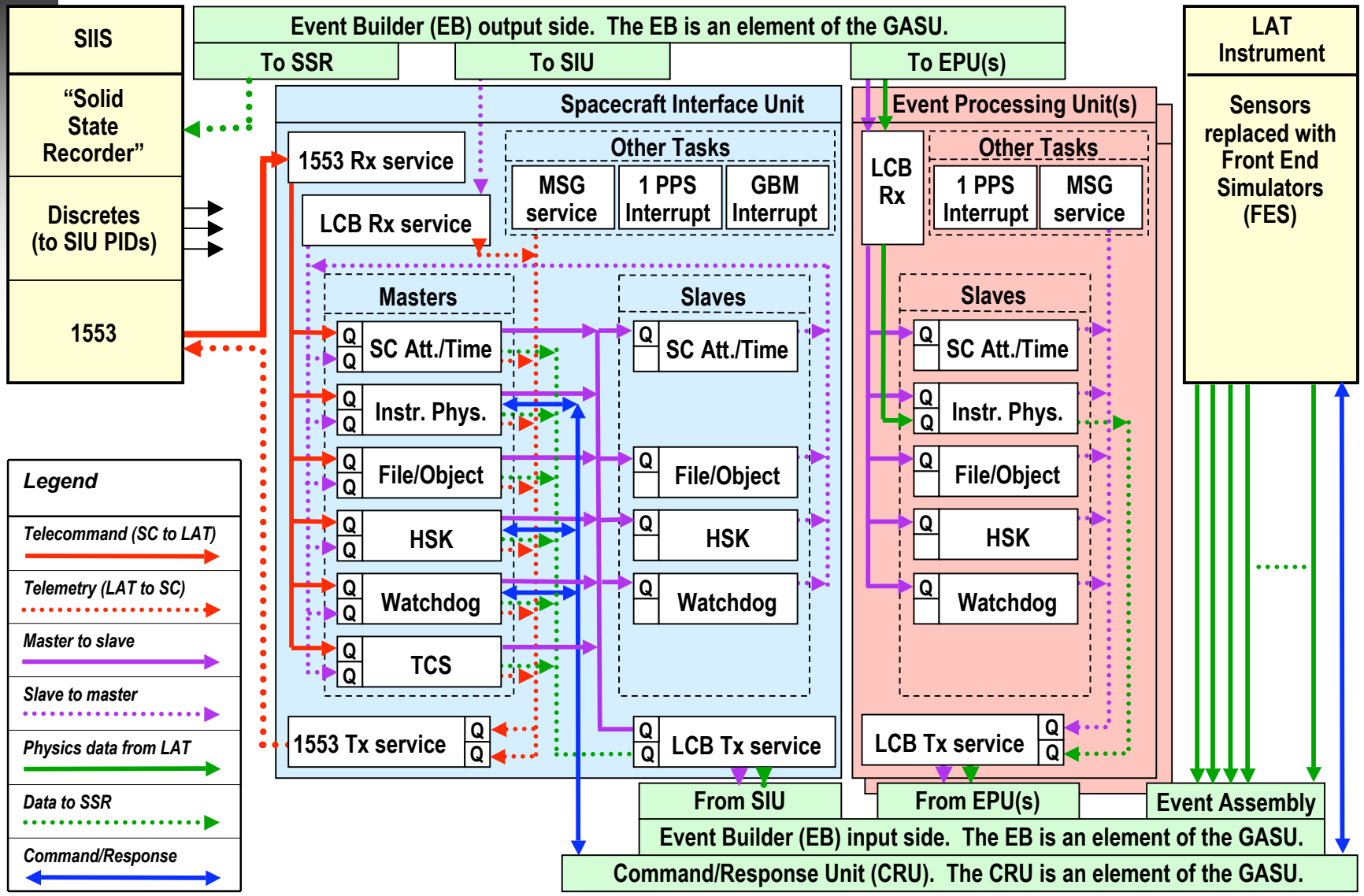
FSW in the ISOC Architecture



FSW and ISOC Interactions

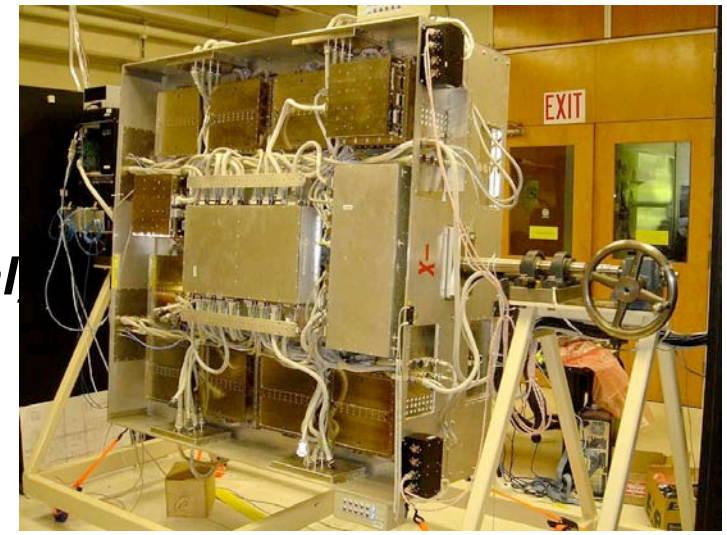
- ***Through FSQ***
  - *Coding the software that will operate the LAT*
  - *Testing the software*
  - *Configuration management*
  - *Development of Test Bed*
- ***Beyond FSQ***
  - *Continue code/test/CM cycle as part of the ISOC operations*
  - *Maintenance of Test Bed*
  - *Review commanding, HK, and performance on a frequent and regular basis*

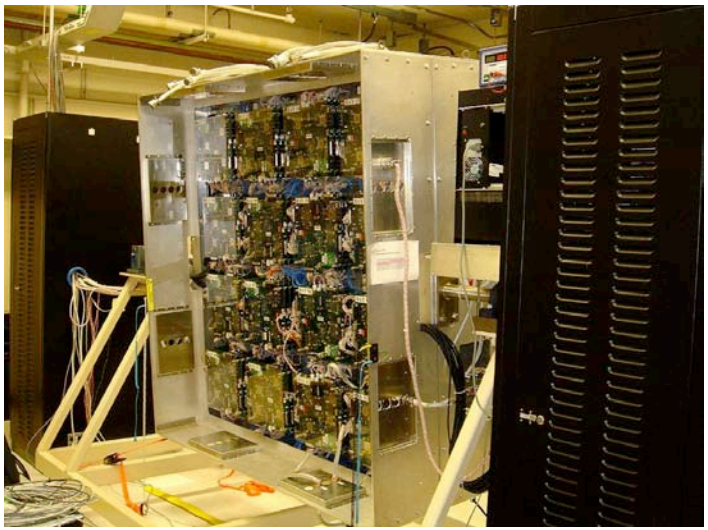
FSW Testbed Block Diagram



FSW Status

- ***Team is in place***
- ***Flight Unit level coding is underway***
- ***Testbed is well underway: functional needs to be fully validated***
- ***SW Integration phase is Q4***
  - *Builds produced as needed to support I&T*
- ***SW Test Scripts underway, completion in Q4***
- ***FSW Qualification Testing begins January 2005***

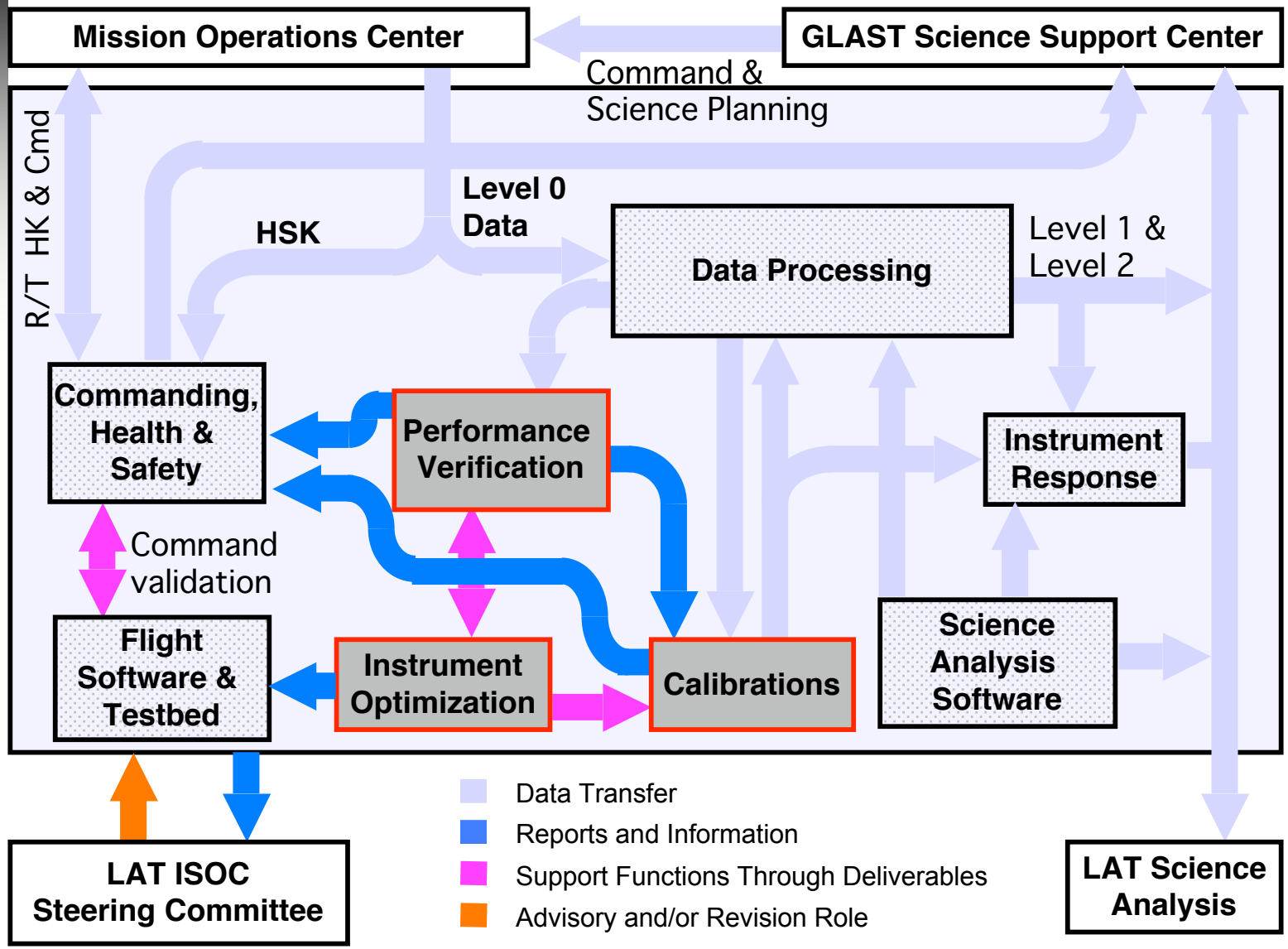




Performance Verification and Optimization

- ***The Performance Validation and Optimization team (PVO) is responsible for:***
  - *instrument calibration from low level through IRFs*
  - *continuous monitoring of the LAT science performance, identification of instrument performance trends and resolution of anomalies*
  - *generation and initial validation of algorithms that improve on-orbit performance of the LAT*
  - *management of test and calibration data collected pre-launch*
  - *Configuration and maintenance of the LAT reference geometry and the LAT Monte Carlo Model*

PVO in the ISOC Architecture



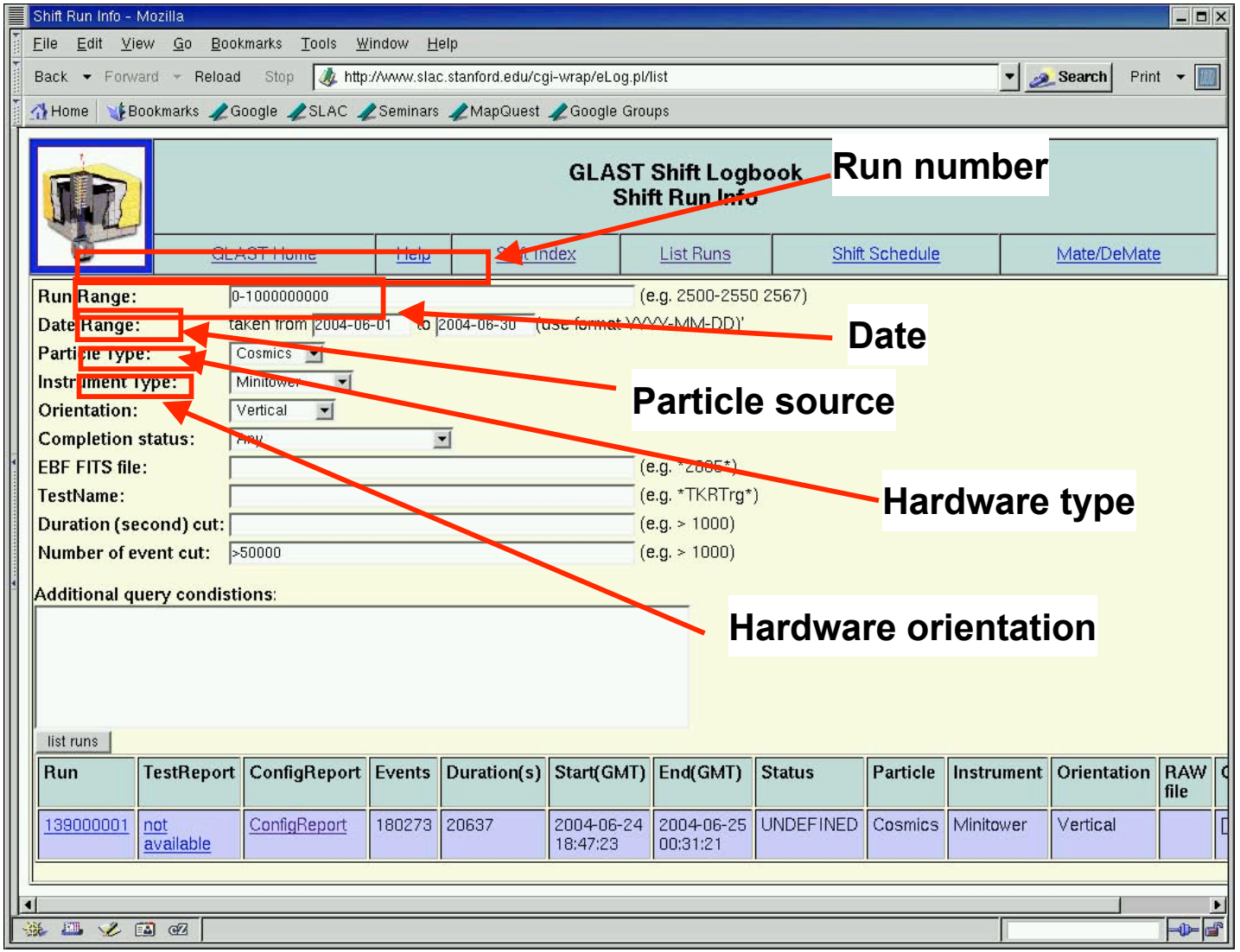
PVO Analysis

- ***Every data set to be analyzed must have information available on the web for easy access on***
  - *Hardware configurations*
  - *Register settings used for data taking*
  - *Quality reports for digitized data*
  - *Quality reports for reconstructed data*

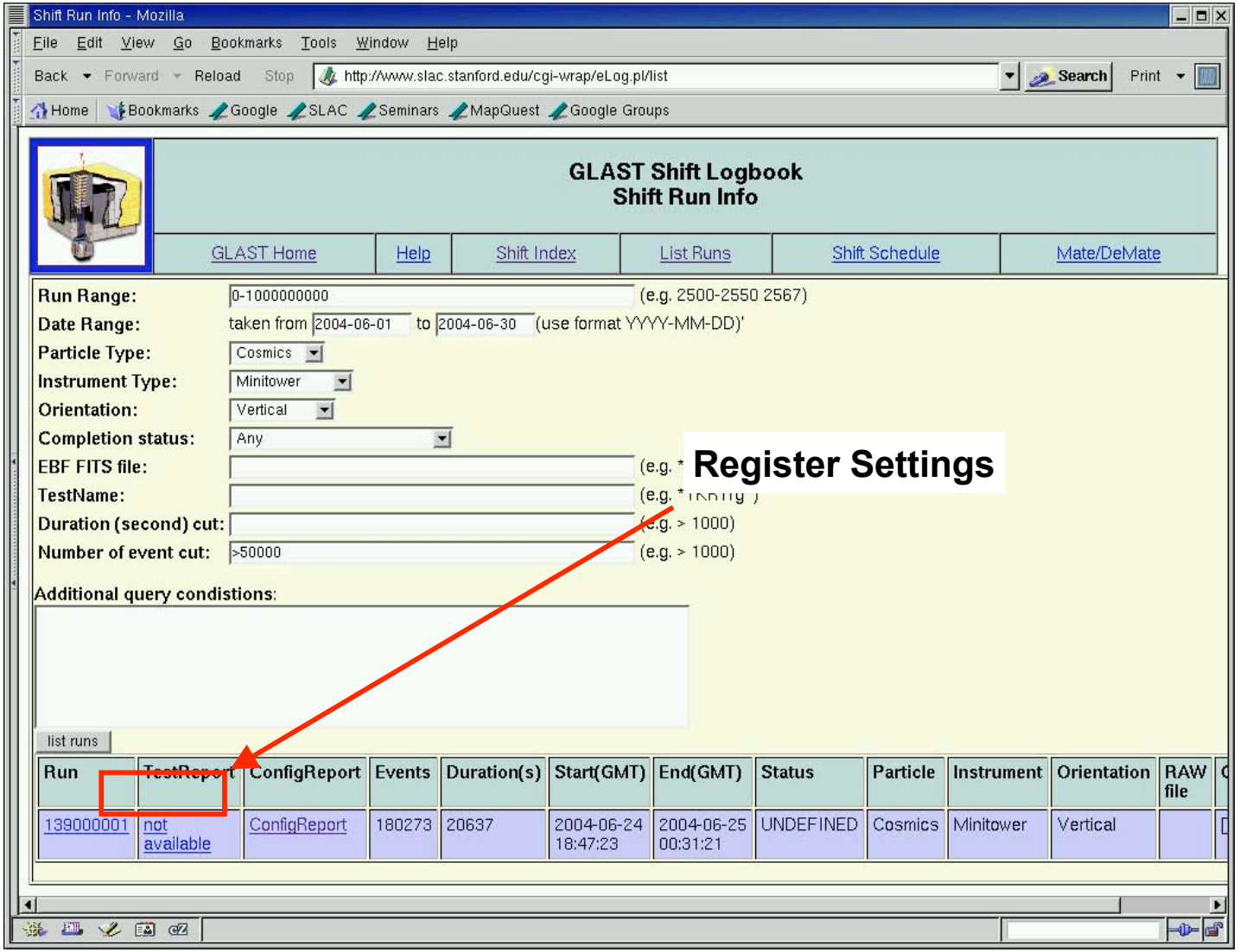
- ***Report generation***
  - *Being implemented as I&T exercises with Engineering Models*
  - *Will continue to develop during transition phases between I&T and ISOC*

The basic infrastructure required for the ISOC PVO team is in place for I&T and forms the basis of our implementation.

Query List of Runs via the Web

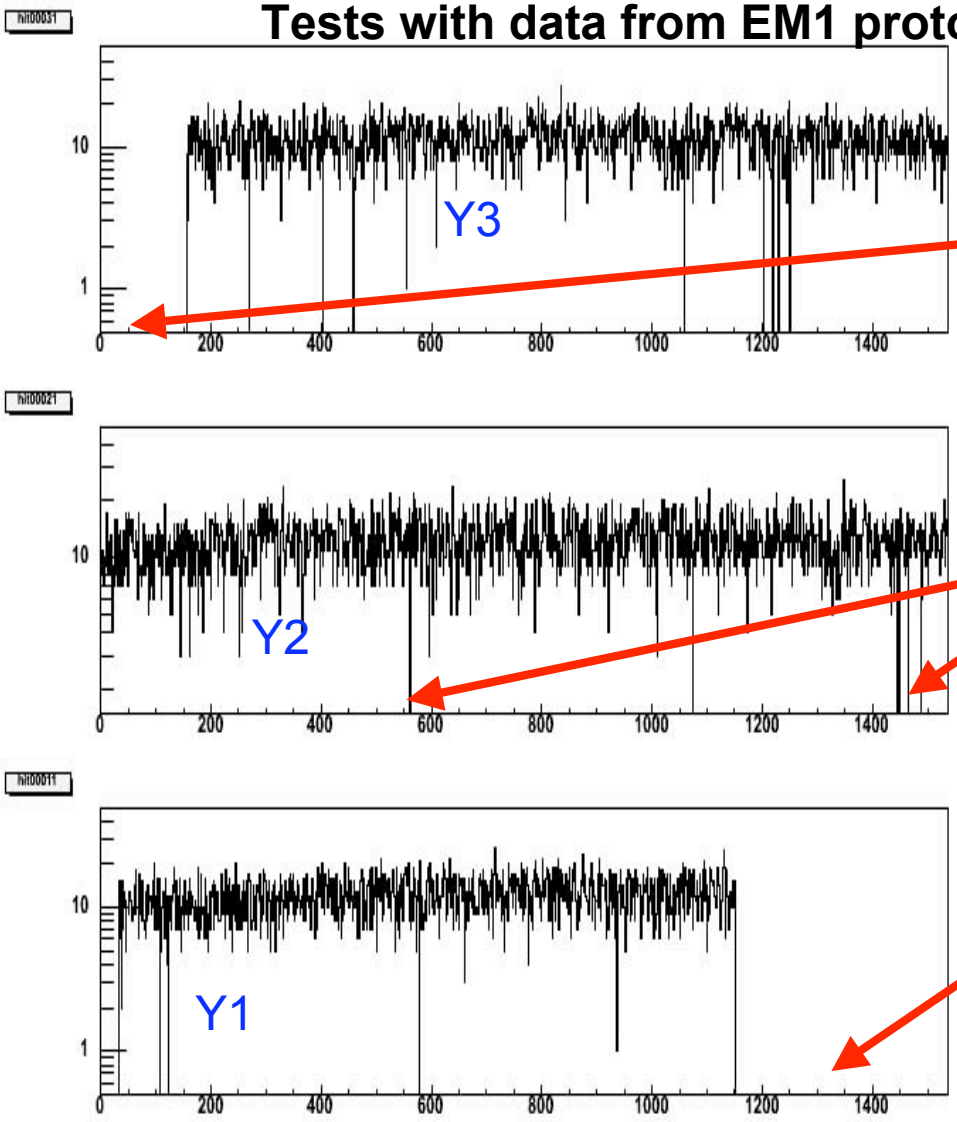


Configuration Report



TKR calibrations example

Tests with data from EM1 prototype



Dead strip xml file

Output Calibration data

<uniplane tray="4" which="bot" >
<stripSpan first= "0" last= "156" />
</uniplane>

<uniplane tray="2" which="top" >
<stripList strips= " 561 1073 1445 1449 1464 1487 " />
</uniplane>

<uniplane tray="2" which="bot”>
<stripSpan first= "1151" last= "1535" />
"</uniplane>

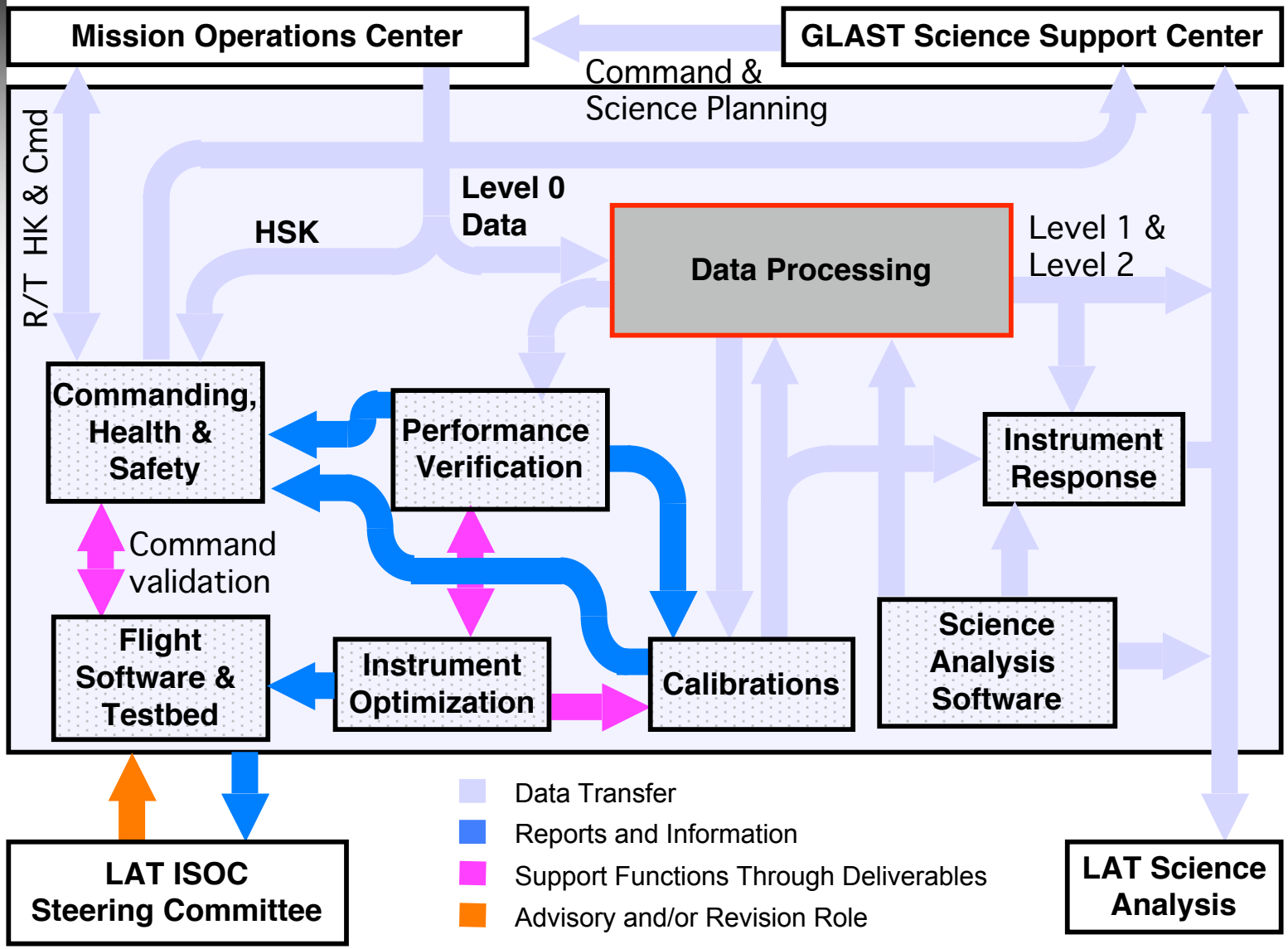
Science Products

- ***The functions developed by the Science Analysis Software (SAS) subsystem of the LAT are leveraged by the Science Products team to provide deliverables for ISOC***

- ***The Science Products Team is responsible for***
  - *Generation, archiving and distribution of the Level 1 data,*
  - *Generation, archiving and distribution of specific Level 2 data needed for reference,*
  - *Transient source detection,*
  - *Configuration control over all pipeline code and generated data sets.*

All science products requirements currently satisfied by work already **completed** by the SAS subsystem.

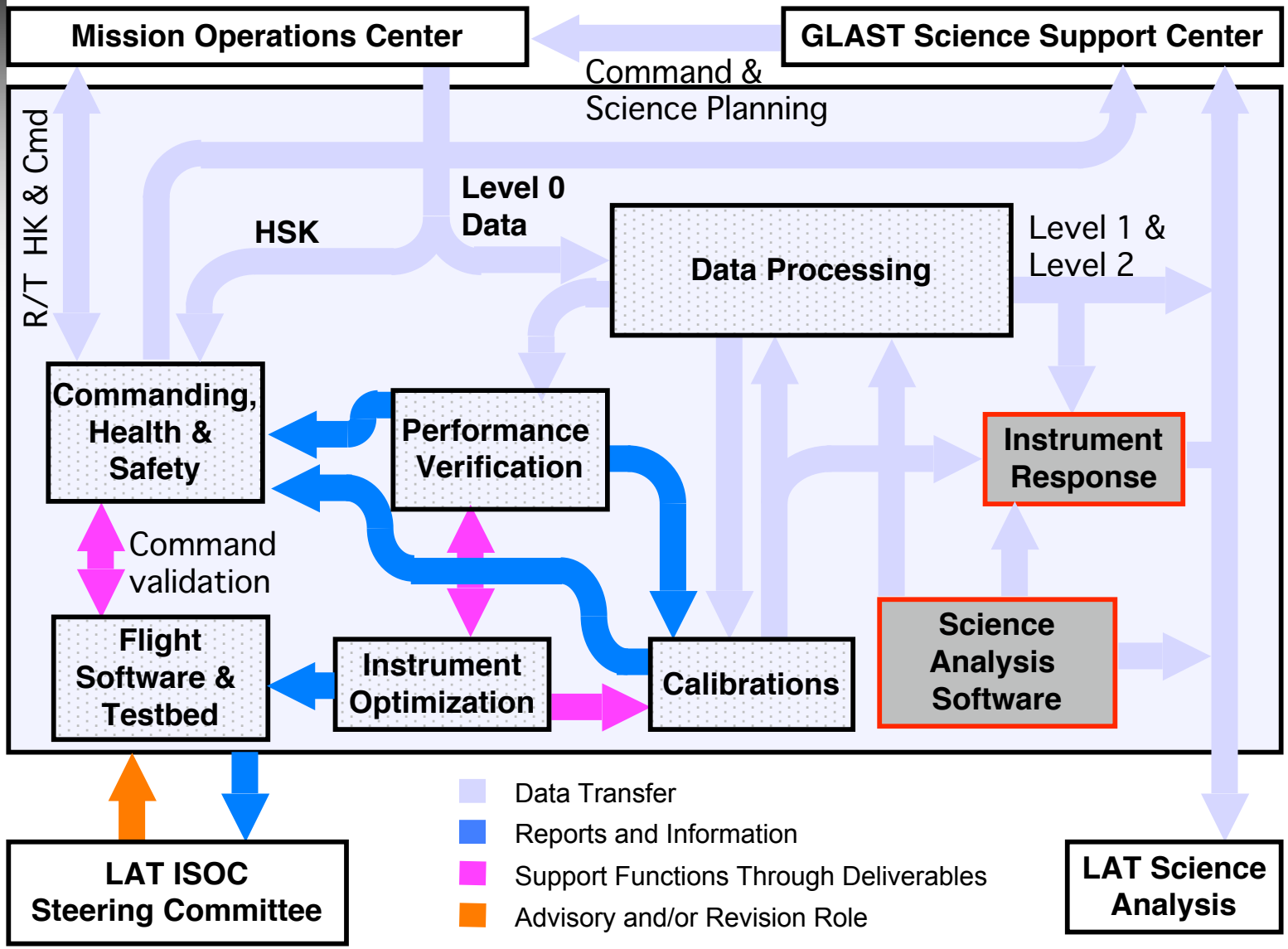
SP in the ISOC Architecture



Science Analysis Software

- ***The Science Analysis Software Team is responsible for***
  - *Development and maintenance of the pipeline machinery*
  - *Development and maintenance of the simulation, reconstruction and event classification software*
  - *Development and maintenance of the calibration algorithms, including low level and Instrument Response Functions*
  - *Development and maintenance of the quicklook transient analyses*
  - *Development and maintenance of the high-level diagnostics derived from reconstruction and classification*
  - *Development and maintenance of the high-level analysis tools*
  - *"Help desk" support of ISOC staff*

SAS in the ISOC Architecture



Overall SAS Test Approach

- ***Combination of Engineering Model tests, Data Challenges and LAT Integration Support***

- ***EM tests***
  - *EM1 demonstrated ability to simulate/reconstruct real data from single (non-standard) tower*
    - *All within standard code framework/tools*
    - *Data analyzed with SAS tools*
- ***Data Challenges***
  - *End to end tests of sky simulation through astro analysis*
  - *Exercise pipeline*
  - *Involve test engineer to check off requirements as part of the DCs*

- ***LAT Flight Integration***
  - *Combine tools from EM & DC applications*
  - *Sim/recon/analysis & pipeline processing and record keeping*

Main Science Tools

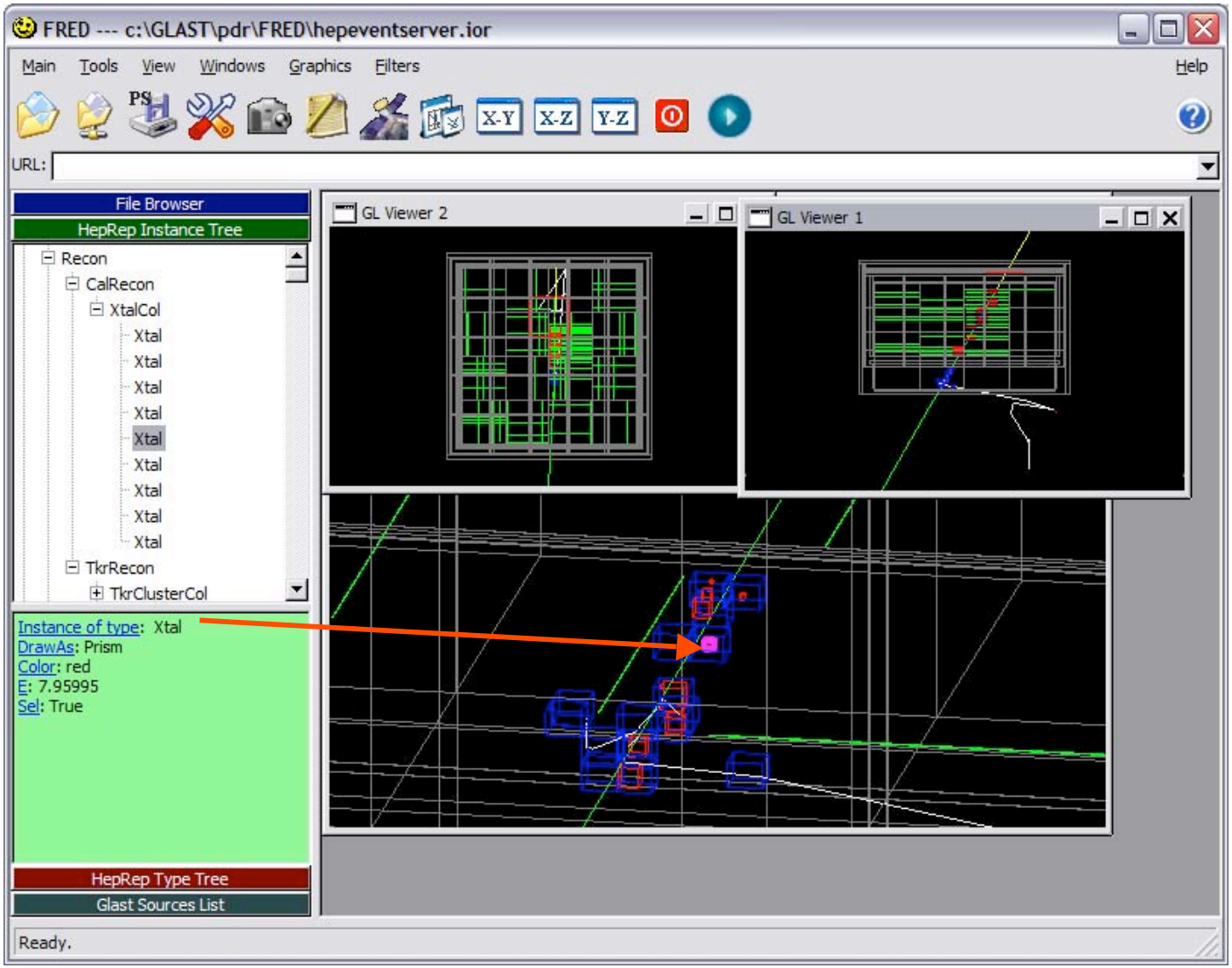
Package	Description	First Use
Likelihood	*Workhorse model fitting for detection & characterization of cosmic gamma-ray sources*	*DC1*
Level 1 database access	*Extracts desired event data*	*DC1*
Exposure calculation	*Uses IRFs, pointing, livetime etc. for deriving calibrated source fluxes*	*DC1*
Source identification	*Identifies gamma-ray sources with cataloged counterparts at other wavelengths*	*DC2*
GRB analysis	*Temporal and spectral analyses of burst profiles*	*DC1*
Pulsar analysis	*Phase folding & period searching of gamma-ray pulsars and candidates*	*DC2*
Observation simulator	*High level simulation of observations of the gamma-ray sky with the LAT*	*DC1*

DC1 = Data Challenge One, February 2004

Science Tools Toolkit

Package	Description	Provider	Status
PIL, PIL++	IRAF parameter access	HEASARC	In use
cfitsio, CCFits	FITS file manipulation	HEASARC	In use
XSPEC, Sherpa	For GRB spectral modeling	HEA standards	Under consideration
Root	gui etc	HEP standard	Under consideration
python	Scripting	World standard	Under consideration
doxygen	Code doc tool	World standard	In use
Visual C++/gnu	Development envs	World standards	In use
CMT	Code mgmt tool	HEP standard	In use
cvsweb	Cvs web viewer	World standard	In use
cvs	File version mgmt	World standard	In use

Example of FRED



Disk and Archives

- ***We expect ~10 GB raw data per day and assume comparable volume of events for MC***
  - *Leads to ~40 TB/year for all data types*
    - *Not a challenge – keep it all on disk*
    - *Have funding approval for up to 200 TB/yr*
  - *Use SLAC's mstore archiving system to keep a copy in the silo*
    - *Already practicing with it and will hook it up to Gino*
  - *Archive all data we touch; track in dataset catalogue*
  - *Not an issue*

Security

- ***Network security – application vs network***
  - *ssh/vpn among all sites – MOC, SSC and internal ISOC*
  - *A possible avenue is to make all applications secure (ie encrypted), using SSL.*

- ***File and Database security***
  - *Controlled membership in disk ACLs*
  - *Controlled access to databases*
  - *Founded on SLAC security (well maintained, high standard)*

Status of SAS

- ***EMs, DCs and Flight Integration will leave us ready for flight***
- ***EM1 worked with our tools***
- ***DC1 worked well, showing very good capabilities from sky modeling through astronomical analysis***
  - *Plenty of work still to do, but reasonably understood*
  - *Will be demonstrated in DC2, 3 and LAT Integration, 16-tower cosmic ray tests and the beam test prior to launch*
- ***LAT Flight Integration prep in full swing now***
- ***DC2 within a year (being negotiated)***

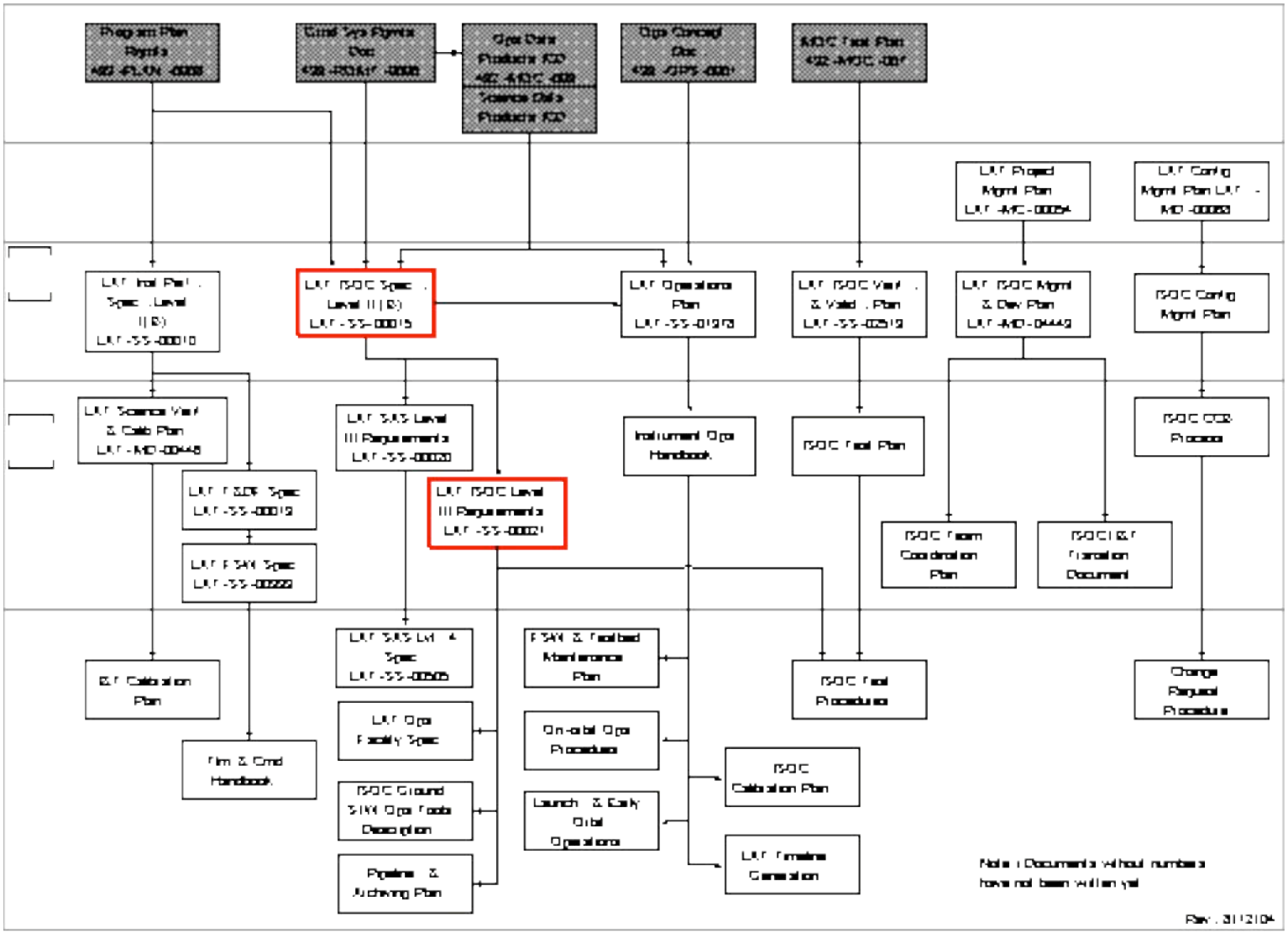
Summary

- ***The majority of code needed for ISOC activities; i.e. the science data pipeline and analysis toolkit, is very mature.***
- ***The verification and optimization tools are being developed by a strong team in I&T with excellent linkages to ISOC***
- ***Overall architecture, and a strong staff, are in place and development beginning***

LAT ISOC
Requirements and Traceability

Jim Martin
SLAC

ISOC Document Tree



Level II Requirements

	Level II
Science Operations	6
Instrument Operations	17
Analysis Software and Data Processing	20
Interfaces	3
Data Standards and Data Format Standards	7
Availability and Reliability	1
Automation	1
Security	1
TOTAL	56

REQUIREMENTS – Level II – LAT-SS-00015

Example - Science Operations

#	Title	Summary	Verification
4.2.1	*LAT Instrument Calibration*	*Produce, monitor and update calibration constants for the instrument*	*T*
4.2.2	*Instrument Response Functions (IRFs)*	*Generate IRFs needed for science analysis*	*T*
4.2.3	*LAT Instrument Performance*	*Assess the LAT instrument performance and compare actual performance against predicted performance.*	*T*
4.2.4	*LAT Instrument Optimization*	*Optimize the LAT instrument in response to in-flight changes in hardware as described in the ISOC Operations Plan, LAT-SS-01378.*	*T*
4.2.5	*Performance Records*	*Archive data on the performance and calibration of the LAT instrument.*	*D*
4.2.6	*Retrieval of Archived Records*	*Retrieve archived performance and calibration data at a rate of at least 1 GB in 60 minutes.*	*T*

Driving Requirements

- *4.3.7 - LAT Instrument Commanding*
  - ***Generate LAT instrument commands and identify procedures to direct the safe upload of the commands.***
- *4.3.9 - LAT Instrument Flight Software*
  - ***Maintain, update, and validate the operation and performance of the LAT flight software.***
- *4.3.10 - LAT Instrument Simulator*
  - ***Maintain an instrument simulator for validating and verifying changes to flight software and command procedures, and also for use in anomaly resolution.***
- *4.4.1 - Level 0 Data Processing*
  - ***Receive Level 0 data from the MOC post-pass and process the data into Level 1 event data within 24 hours of receipt from the MOC.***
- *4.4.2 - Real-time Housekeeping Data*
  - ***Autonomously receive real-time housekeeping data in near real-time from the MOC and process the data for diagnostic use.***
- *4.4.6 - Instrument Response Simulation*
  - ***Develop and maintain software to simulate the detailed response of the LAT to charged particles and gamma rays.***
- *4.4.5 - Event Reconstruction and Classification*
  - ***Develop algorithms to interpret the subsystem responses, apply calibration constants, and to find and identify incident photons.***

REQUIREMENTS – Level III – LAT-SS-00021

		# of Level III
3.1	**Configuration and Architecture**	**60**
3.1.1	*Interface*	**10**
3.1.2	*Facilities*	**11**
3.1.3	*Redundancy*	**6**
3.1.4	*Security*	**6**
3.1.5	*Database*	**5**
3.1.6	*Website*	**6**
3.1.7	*Documentation*	**4**
3.2	**Mission Planning & Scheduling**	**62**
3.2.1	*Flight Dynamics*	**3**
3.2.2	*TDRSS scheduling*	**2**
3.2.3	*Target of Opportunity*	**8**
3.2.4	*Stored Command Load Generation*	**49**

REQUIREMENTS – Level III – LAT-SS-00021

Continued – 2/3

		# of Level III
3.3	**Telemetry, Command & Data Processing**	**85**
3.3.1	*Telemetry Processing*	**29**
3.3.2	*Data Processing*	**19**
3.3.3	*Data Archiving*	**10**
3.3.4	*Alert Telemetry Monitoring*	**1**
3.3.5	*User Interface Language*	**22**
3.3.6	*Commanding*	**4**

REQUIREMENTS – Level III – LAT-SS-00021

Continued – 3/3

		# of Level III
3.4	**Monitoring and Analysis**	**176**
3.4.1	*Ground System Monitoring*	**4**
3.4.2	*Display Pages*	**38**
3.4.3	*Sequential Prints*	**15**
3.4.4	*Event Messages*	**13**
3.4.5	*Memory Mapping & Maintenance*	**7**
3.4.6	*Limit Monitoring*	**14**
3.4.7	*Configuration Monitoring*	**15**
3.4.8	*Trending & Analysis*	**32**
3.4.9	*Anomaly Tracking & Notification*	**29**
3.4.10	*Timeline Monitoring*	**3**
3.4.11	*Calibration & Performance*	**6**

Traceability and Testing

- ***Level II and Level III moved to Doors***
  - *Leverages LAT's use of Doors for fabrication phase*
- ***Have begun mapping***
  - *II to III*
  - *II to higher levels*
- ***Will include testing: references to documents describing procedures and results***

Summary

- ***Requirements are in the signature cycle***
  - *Review and update as needed after GSDR*
- ***Development approach tailored to Level III***
- ***Ready to develop***

LAT ISOC
Command, Health and Safety Design

Lori Bator
SLAC ISOC Lead Engineer

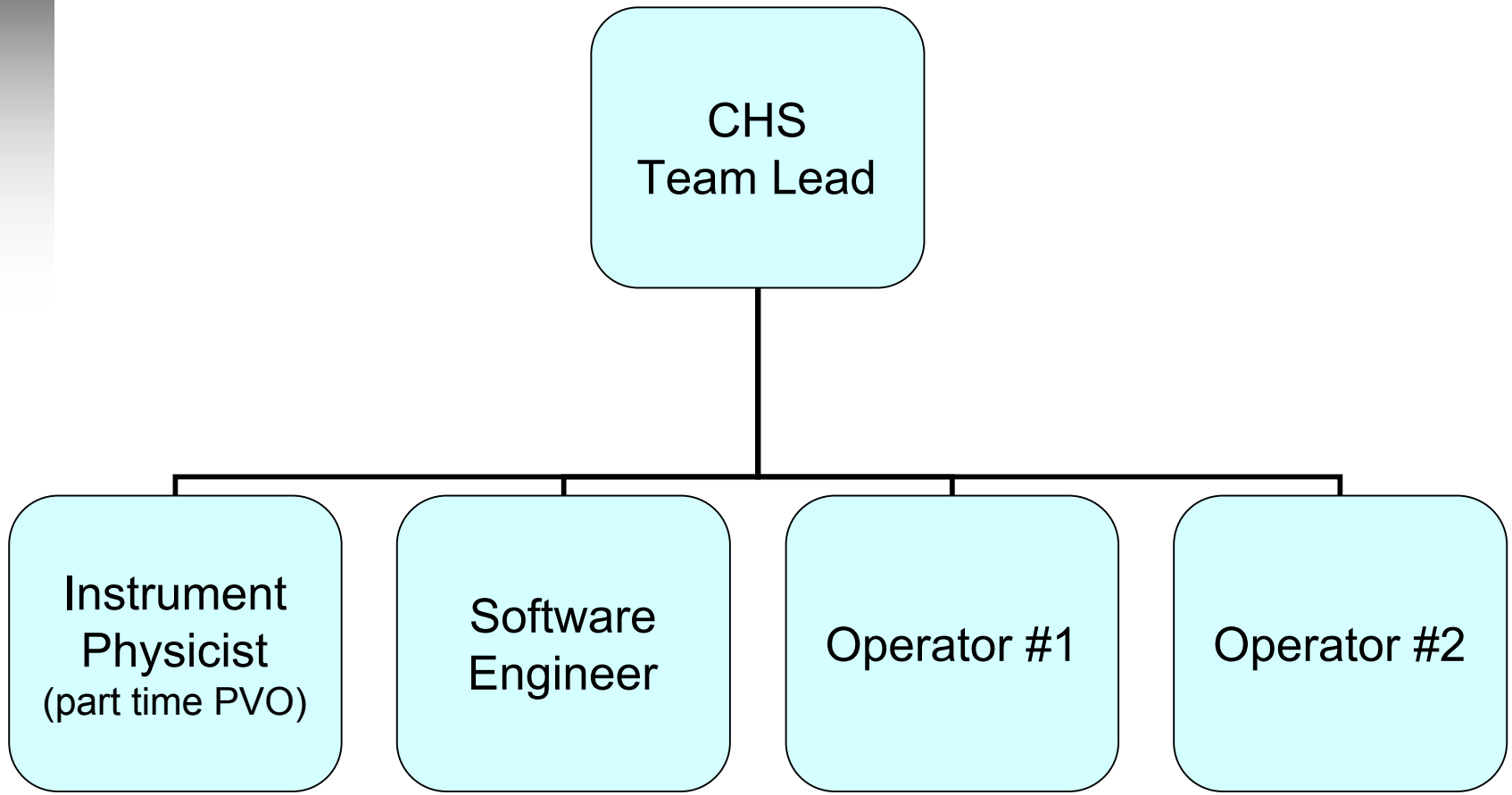
Commanding, Health and Safety

- ***The Commanding, Health and Safety (CHS) team is responsible for:***
  - *generation and validation of commands and command sequences,*
  - *passing commands on to the GSSC,*
  - *verifying these commands were executed,*
  - *receiving Level 0 data from the MOC,*
  - *logging and archiving of all commands and Level 0 data,*
  - *monitoring that data to ascertain and track the health and safety of the instrument,*
  - *continuous knowledge of the configuration of the LAT.*

CHS System

- ***ITOS used for command, health and safety functions***
  - *HK data limit checking*
  - *Telemetry and command definition file validation*
  - *Command load verification and validation*
- ***Other tools***
  - *Level 0 receipt and archiving*
  - *HK trending*
  - *Data transmission*
  - *Mission planning and generation of file uploads*
  - *Anomaly tracking and notification*
  - *Relational database queries for trending and analysis*
  - *Configuration management tools*

CHS Team (1/3)


CHS
Team Lead
Instrument
Physicist
(part time PVO)
Software
Engineer
Operator #1
Operator #2

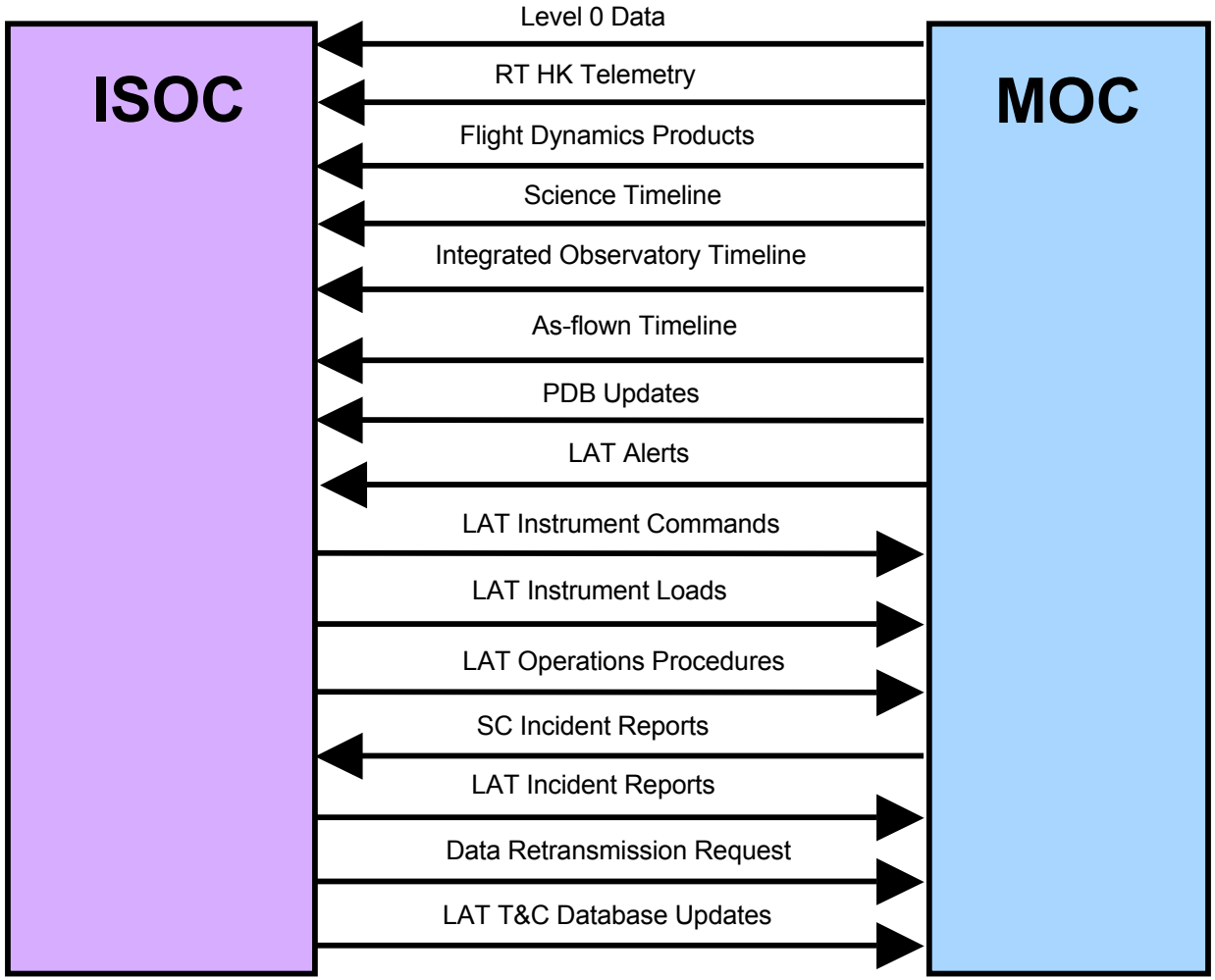
CHS Team (2/3)

- ***Weekday, day-time operations***
  - *Operator shift coverage*
    - *5 am to 2 pm to cover MOC shift times on East Coast*
    - *9 am to 6 pm to cover ISOC internal coordination needs*
  - *On-call support*
    - *Operators for real-time commanding or anomaly support*
    - *Software engineer for emergency software support*
    - *Team Lead and Instrument Physicist for anomalies*
- ***Instrument Physicist***
  - *Monitor HK data for impact on science*
  - *Monitor and maintain configuration of instrument*
  - *Schedule instrument commanding*

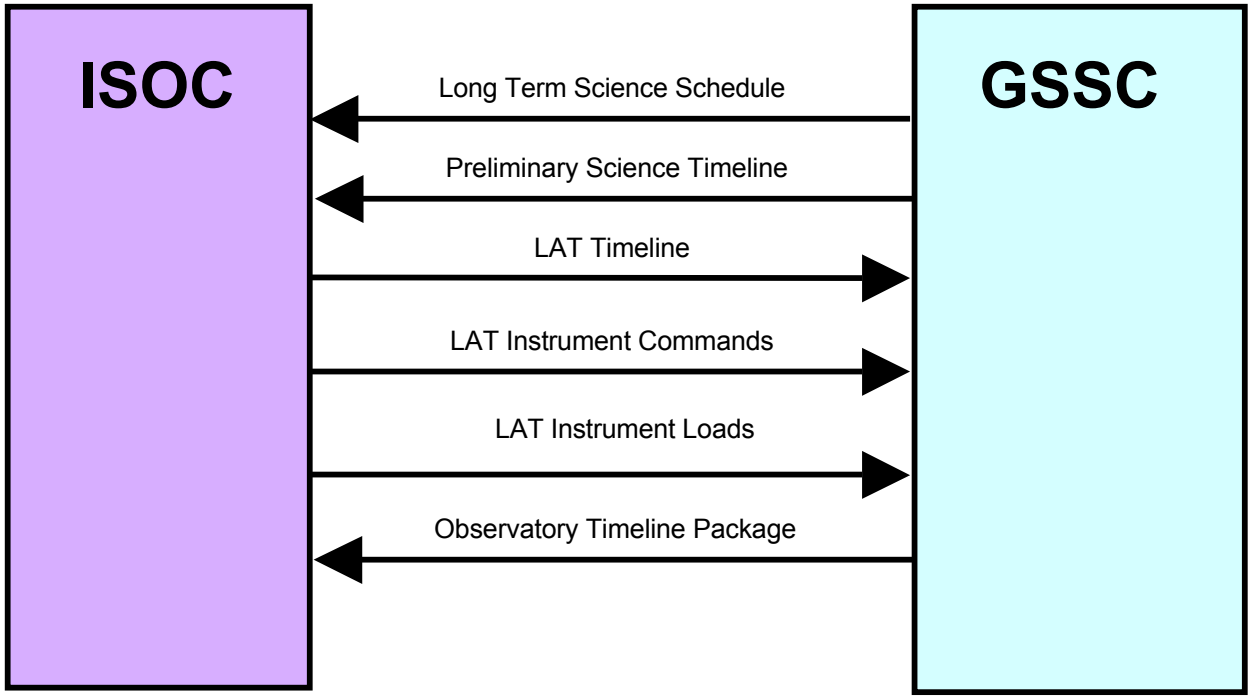
CHS Team (3/3)

- ***Software Engineer Responsibilities***
  - *Maintain ITOS configuration and other CHS tools*
  - *Maintain configuration control of command and telemetry database*
- ***Operator Responsibilities***
  - *Generate LAT commands*
  - *Interface with MOC and GSSC*
  - *Monitor CHS system processes*
  - *Monitor real-time contacts during the shift*
  - *Monitor automated report generation*
  - *Respond to notification of alerts and anomalies*
  - *Serve as backup for Software Engineer to address system problems*

Ops Data Products: ISOC – MOC



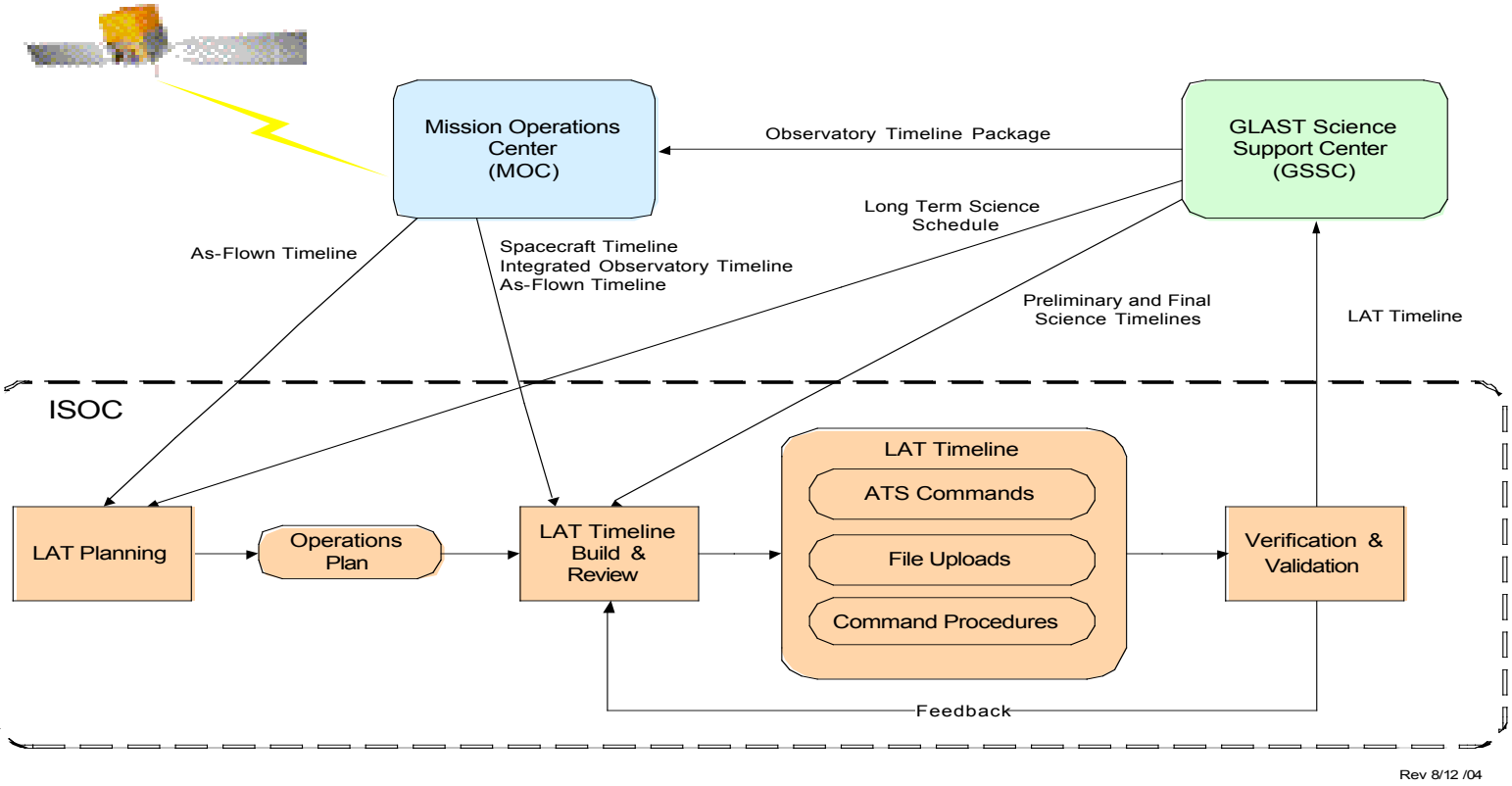
Ops Data Products: ISOC – GSSC



LAT ISOC
Operations Planning & Scenarios

Lori Bator
SLAC ISOC Lead Engineer

LAT Operations Planning and Command Process



Science Planning

- ***Phase 0/1: ISOC maintains LAT science plan***
  - *Organization of the scientific activities of the LAT collaboration outside of the ISOC is still being defined*
    - *Topic at next collaboration meeting, Sept. 27-29 at SLAC*
  - *Committee with collaboration and probably Project Scientist representation to oversee LAT operations planning and serve as the interface between science and operations*
    - *Acceptance of updated algorithms for the LAT trigger or event filtering (onboard or ground)*
    - *Definitions of conditions when the LAT will autonomously request a repointed observation*
- ***Phase 2: GSSC generates Long Term Science Schedule***
  - *GSSC assists in overall science schedule evaluation and will manage the guest investigator proposal process*
  - *Coordinated with LAT collaboration*
  - *Input to LAT Planning*

Operations Plan

- ***Description of LAT operations for one month***
- ***Derived from***
  - *Evaluated performance of the LAT*
  - *As-flown timeline*
  - *Science plan [Phase 1] or Long Term Science Schedule [Phase 2]*
  - *Calibration needs*
- ***In general the operations plan will have no impact on the pointing of GLAST***
  - *For a scanning sky survey (Phase 1 and likely also most of Phase 2), the 'science activities' are the same all the time*
  - *Calibration needs occasionally will require special observing modes or scheduling of more than the usual number of TDRS contacts*
  - *Most calibration data taking will not require specific orientations for GLAST*
    - *Occasional exceptions will be, e.g., pointed observation of 'standard candle' celestial sources or possibly scans of the Earth limb and the nadir to characterize the albedo background*

LAT Timeline

- ***Contains all LAT commanding information to fulfill a one-week period of the Operations Plan***
  - *Commands for Absolute Time Sequence (ATS)*
  - *File loads*
    - *Table uploads*
    - *Configuration changes*
    - *FSW loads*
  - *Command procedures*
    - *Commands requested to be sent in real-time*
- ***Generated by CHS team about 2 weeks before upload***
- ***Coordinated with GSSC, MOC and GBM through weekly planning meetings***
- ***Validated and verified on testbed***

Status

- ***Continuing to finalize details of commanding process with GSSC and MOC through***
  - *Weekly GOWG meetings*
  - *Ops TIMs*
  - Operations Data Products ICD *(492-MOC-009)*
  - Operations Agreement
- ***LAT operations planning documented in* ISOC Operations Plan (*LAT-SS-01378)***

LAT Operations Scenarios

LAT Operations Phases

- ***LAT I&T***
  - *Pre-FSW (EM)*
  - *Post-FSW (Flight unit level)*
- ***Observatory I&T***
  - *NRL*
  - *Spectrum*
- ***Launch and Early Orbit (L&EO) – Phase 0***
  - *LAT power-on and configuration*
  - *Initial checkout*
- ***First year – Phase 1***
  - *Survey mode*
- ***Second and subsequent years – Phase 2***
  - *Pointed observation*
  - *Survey mode*

Pre-launch Testing

- ***LAT I&T Phase Tests***
  - *Verify and validate development of ISOC tools and functions on testbed and through software simulation*
- ***Data Challenges***
  - *"End to end" test of science analysis software*
- ***Ground Readiness Tests (GRTs)***
  - *Verify and validate system interfaces and data flows*
- ***Observatory I&T Phase Tests***
  - *Verify and validate ISOC capabilities*
- ***End-to-End (ETE) tests***
  - *Verify and validate interface between ground system and observatory*
- ***Mission Simulations***
  - *Verify operation team readiness prior to launch*

Initial Turn-On and Checkout (Phase 0)

- ***Turn-on (power-up) procedure will not be executed automatically***
  - *Humans required to check environmental conditions prior to significant steps*
  - *Must establish correct LAT configuration to ensure communications*
- ***Functional checkout of DAQ, ACD, CAL and TKR***
- ***Perform initial calibrations***
- ***Special requirements***
  - *ACD will have control of triggering; therefore no science data taking available for ~ 3 days*
  - *Monitor phototube high voltages in ACD during turn-on*

Science Operations (Phases 1 and 2)

- ***Data taking***
  - *Continuous*
  - *A few commands to initiate*
- ***Calibration***
  - *Weekly, biweekly and monthly*
  - *A few commands to initiate*
- ***Load changes to tables and FSW***
  - *Infrequent*
  - *A few commands and/or file uploads which may be large*
- ***Load new tables and files***
  - *Infrequent*
  - *A few commands and/or file uploads which may be large*
- ***Diagnostics***
  - *Infrequent*
  - *A few commands and/or file uploads which may be large*
- ***SAA management***
  - *FSW turns down high voltage automatically based on SAA message from S/C*

Monitoring Requirements

- ***LAT FSW monitors parameters onboard and will take action (power-off or stop activity) in response to limit violations***
- ***S/C monitors some temperatures and will power off LAT if needed***
- ***MOC monitors HK data for limit violations***
  - *No critical monitoring or actions required*
  - *ISOC will provide limits in LAT T&C database*
  - *ISOC will provide and direct use of any contingency procedures*
- ***ISOC monitors HK and Science data for limit violations and trends***
  - *Respond to degradation, noise, changes in performance, and failure by uploading commands or files to change configuration*
  - *No critical monitoring except during power-up*

Status

- ***ISOC operations concept documented in LAT-SS-01378* LAT Operations Plan**
- ***Detail on operations will evolve from FSW development and I&T tests***
  - *Detail will be captured in* Operations Handbook *(ECD Oct 2005) and* Operations Procedures *(ECD L-6 months)*
    - *Command sequences*
    - *Constraints*
    - *Contingency actions*

LAT ISOC
Software Architecture

Steve Culp
SLAC

Topics

- ***Requirements Mapped to Software***
- ***Software Architecture***
- ***Network and Hardware Architecture***
- ***Status***

Requirements Mapped to Software

- ***Each requirement was identified as:***

1.	*Procedural (non-software)*	*42*
2.	*Existing software (commercial or other well-established software -- i.e. implementation Done!)*	*277*
3.	*Under development by SAS (mostly done, refer to SAS for status)*	*39*
4.	*To be developed by others (I&T, FSW, ITOS)*	*21*
5.	*Remaining new development*	*88*
	total	*467*

- ***Some requirements map to multiple categories or SW tools, so total exceeds total number of level IIIs (379)***

1. Procedural (no SW development)

Name	# Level 3 Reqts	% of Reqts
N/A (e.g. facility reqts)	19	4.1%
Ops Procedures	12	2.6%
SCS (SLAC Computer Services)	11	2.4%
Total	42	9.0%

2. Existing software

Name	Description	# Level 3 Reqts	% of Reqts	Source
ITOS	satellite C&T package	215	46.0%	GSFC
ATNS	Anomaly Tracking and Notification System	32	6.9%	FASAT (commercial) or RXTE SOF Process Mgr (RXTE)
FastCopy / DTS	secure file transfer	15	3.2%	FastCopy (commercial), DTS (HEASARC)
CVS	file config mgmt tool	5	1.1%	Open Source
STK	Satellite Tool Kit	4	0.9%	commercial
LATDocs	LAT documentation management tool	4	0.9%	existing SLAC LAT tool
NTP	synchronize computers	1	0.2%	Open Source
email	electronic mail	1	0.2%	Open Source
Total		277	59.3%	

3. Under Development by SAS

Name	Description	# Level 3 Reqts	% of Reqts
GINO	pipeline manager	21	4.5%
DATACHKTOOL	check quality of science data telemetry	6	1.3%
SASTOOL1	generate level 1 science data products	6	1.3%
SASTOOL2	generate level 2 science data products	4	0.9%
SASAUTO	manage automatic generation of level 1 & 2 data products	2	0.4%
Total		39	8.4%

4. To be developed by others

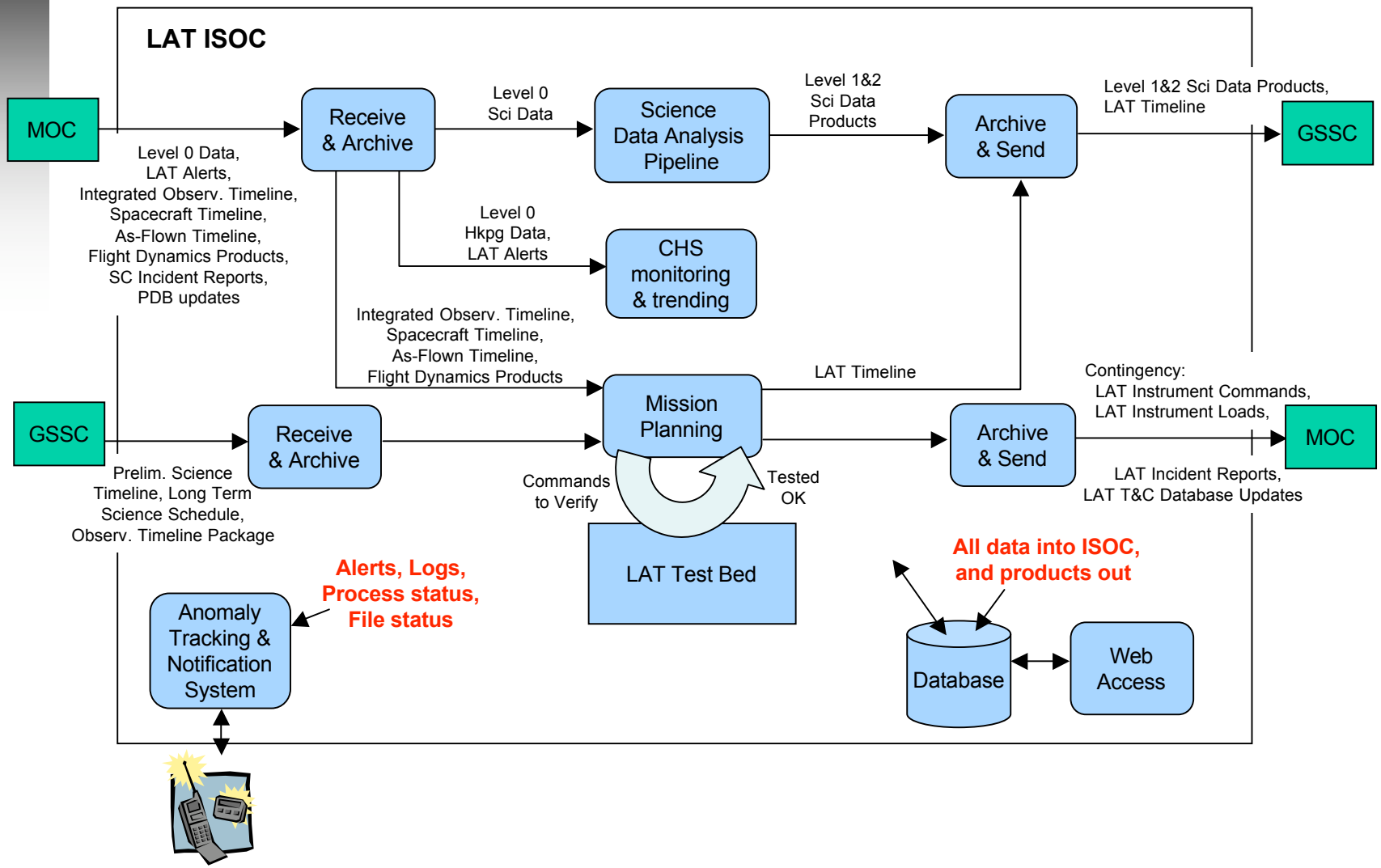
Tool Name	Description	# Level 3 Reqts	% of Reqts	Source
ELOG	electronic log book	8	1.7%	I&T Online (mostly done)
DIAGTOOL	diagnostic access	7	1.5%	FSW
ITOS Enhancements	minor changes to ITOS to meet specific reqts	3	0.6%	GSFC
IRFTOOL	generate instrument response function	2	0.4%	SVAC
DBCAL	create database of LAT calibration data	1	0.2%	SVAC
Total		21	4.5%	

5. Remaining to be developed

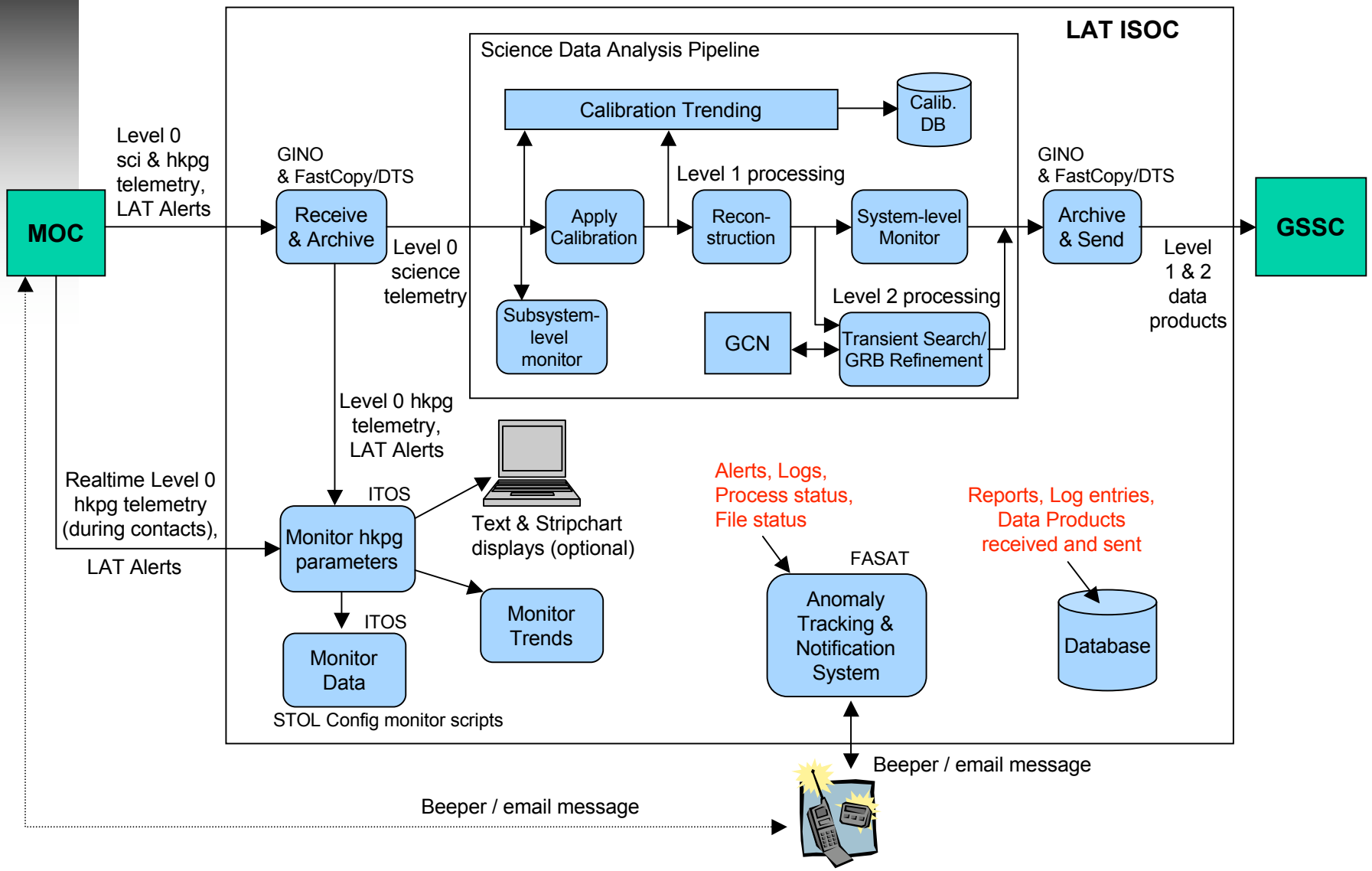
Tool Name	Description	# Level 3 Reqts	% of Reqts	Comments
PLOTTOOL	plotting	28	6.0%	combination of existing tools (e.g. ROOT, HippoDraw, JAS, IDL) & new dev
TRENDTOOL	trending	16	3.4%	combination of IDL, DTAS (used by MOC), and/or TAPS (GSFC)
PLANTOOL	mission planning	6	1.3%	generate timeline and commands for LAT operation
CONSTRAINT TOOL	check command sequences against constraints	12	2.6%	
DB	database definition and implementation	10	2.1%	partially done by SAS, I&T, FSW - coordinating dev with SAS, I&T, FSW, SCS
DBIN	ingest ISOC data	7	1.5%	
WEBTOOL	provide web access to data products	9	1.9%	
Total		88	18.8%	

Software Architecture

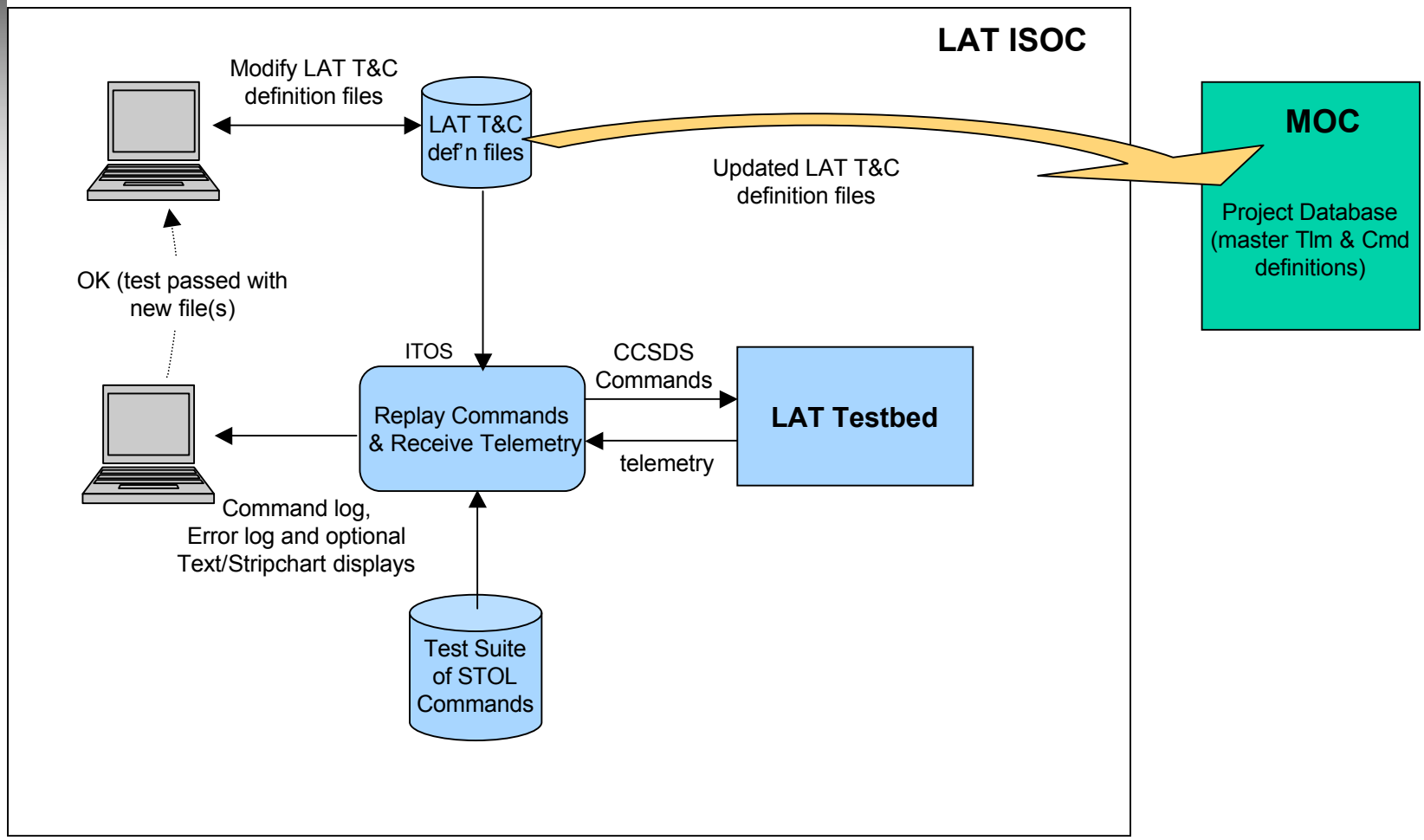
Primary Data Flows



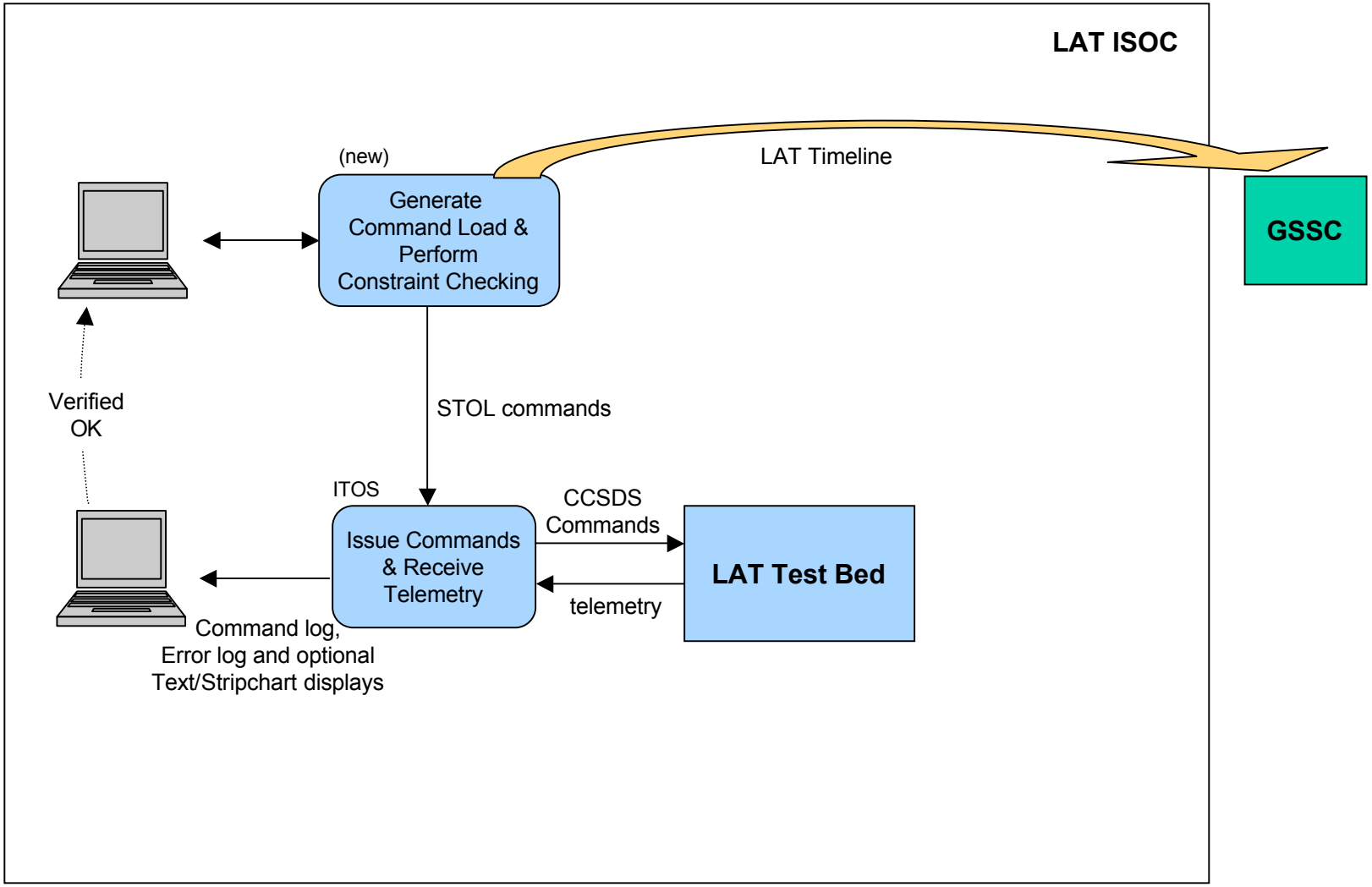
Automatic Telemetry Processing



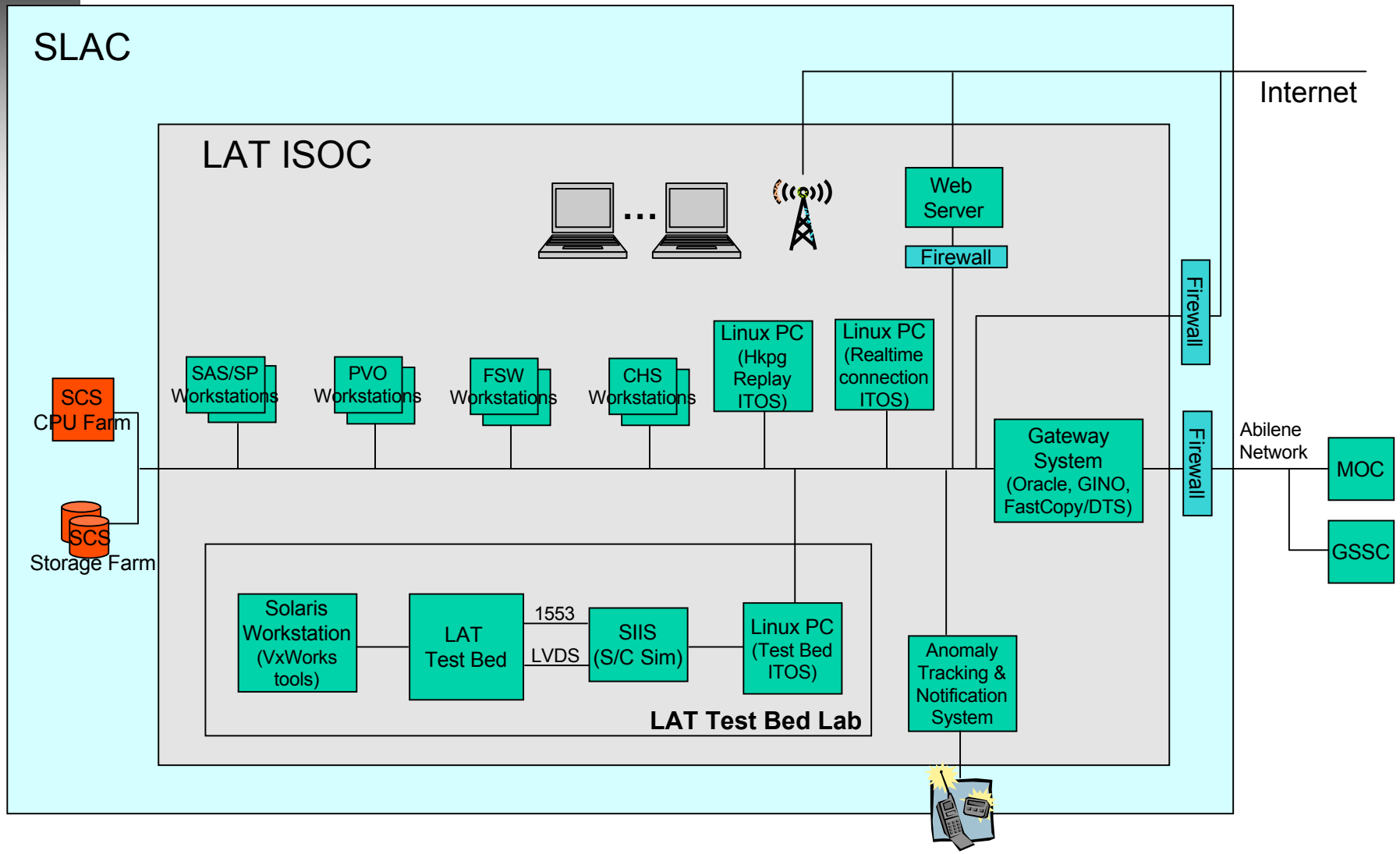
Telemetry & Command Definition File Verification



Command Load Generation & Verification



ISOC Network and Hardware Architecture



Status

- ***Architecture concept is solid***
- ***Ready to proceed***
  - *Refine and document software design*
  - *Implement it*
  - *Lots of testing and demos*

LAT ISOC
Management, Cost, Schedule

Bill Craig
SLAC

ISOC Management Process

- ***The ISOC has established the following meetings in support of ISOC development and coordination:***
  - *Weekly ISOC staff meeting to track schedule, RFAs and any coordination issues.*
  - *Weekly ISOC-FSW coordination meeting, attended by ISOC staff and the FSW manager, to work issues of joint importance and ensure that jointly held requirements are executed in the most efficient manner.*
  - *Bi-weekly meetings between ISOC manager and GLAST project scientist to work overall science planning and mission issues.*
  - *Database development meetings.*
  - *Regular interaction with I&T including shared personnel.*
- ***Participate in:***
  - *Weekly GOWG meeting with GSFC*
    - *Address ICDs, timeline, and operation issues*
  - *Weekly FSW, I&T, SAS working group meetings*
    - *Coordinate script development and test activities*

Test Philosophy

- ***Schedule constructed to test as early as possible***
  - *LAT testbed allows frequent and meaningful tests while instrument is being assembled*
  - *Data challenges already testing full science data pipeline*
  - *I&T optimization and calibration tools validated and tested*
- ***Frequent demonstrations and simulations precede major software releases.***
- ***Six end to end tests during Observatory I&T to provide confidence in final major release of software.***

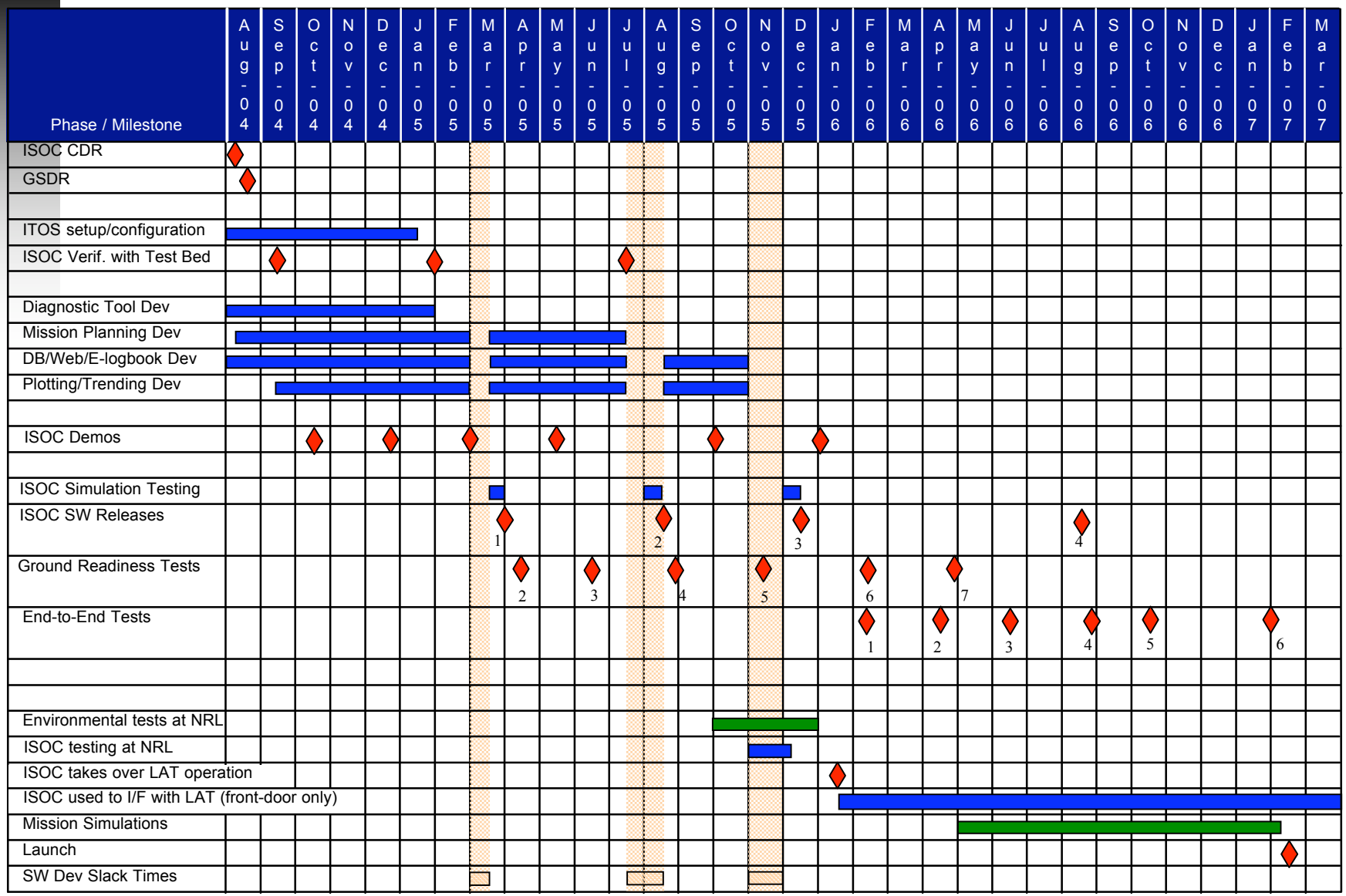
ISOC Software Release Schedule

- ***New software architecture in place, centralizing all software releases; eliminating the various separate software release schedule as in the PDR schedule***
- ***The schedule has been coordinated with GSFC Ground System plans***
  - *ISOC Software Release 1 (April 1, 2005)*
    - *Support Ground Readiness Test (GRT) 2 and 3*
  - *ISOC Software Release 2 (August 15, 2005)*
    - *Support GRT 4 and 5*
  - *ISOC Software Release 3 (December 15, 2005)*
    - *Support End-to-End 1, ETE 2, ETE 3, GRT 6, GRT 7, and Mission Sim*
  - *ISOC Software Release 4 (July 25, 2006)*
    - *Support remaining ETE's 4, 5, and 6*

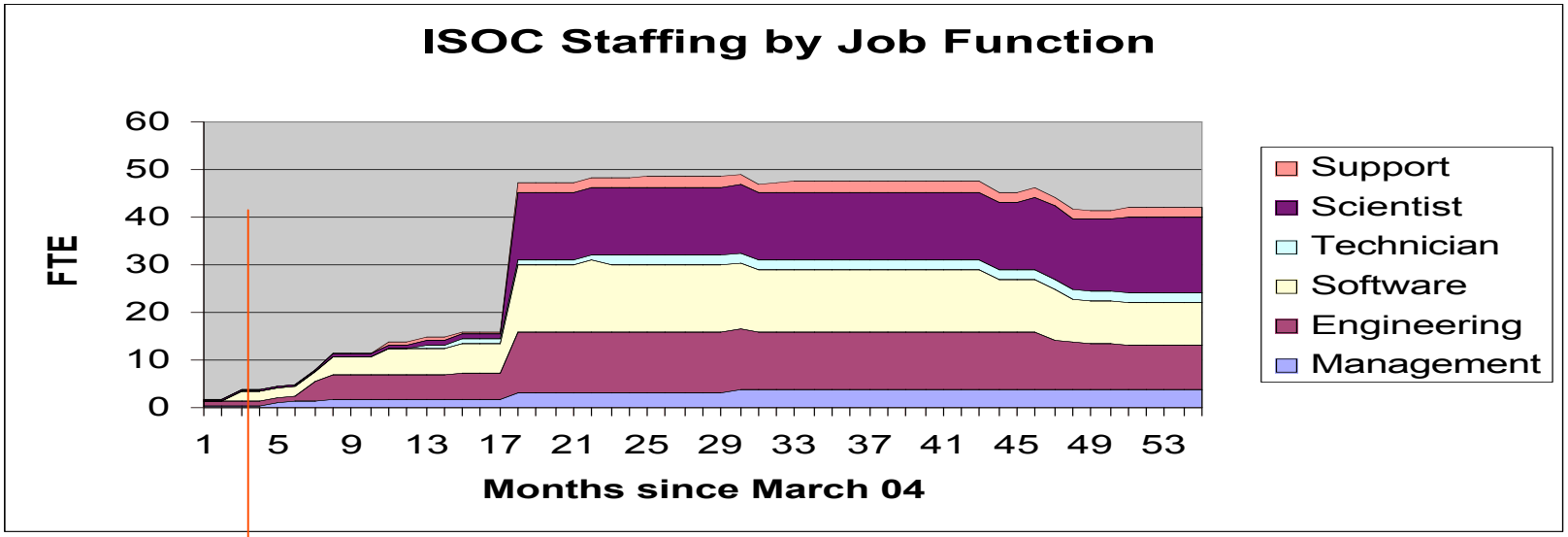
ISOC S/W Summary for GRTs & ETEs

Date	What	Release	Required ISOC capabilities
15-Apr-05	GRT 2	ISOC 1 (1 Apr 05)	receive real-time HK data from MOC, provide basic LAT P&S (Planning & Scheduling)
15-Jun-05	GRT 3	"	level 0 data processing on science data, IOC processes science level 0 data into level 1 products
1-Sep-05	GRT 4	ISOC 2 (15 Aug 05)	receive level 0 data from MOC
15-Nov-05	GRT 5	"	provide level 1 and 2 data products to GSSC, provide more complex LAT P&S, provide LAT file uploads to GSSC, provide simulated science data
11-Feb-06	ETE 1	ISOC 3 (15 Dec 05)	provide Level 1 data products to GSSC, receive Level 0 files from MOC (post-test)
15-Feb-06	GRT 6	"	contingencies added
15-Apr-06	ETE 2	"	provide instrument commands and file loads, support memory dumps of instrument
1-May-06	GRT 7	"	clean-up and regression tests
1-May-06	Mission Sims	"	full ISOC capabilities to support Mission Sims (from May 2006 through launch)
15-Jun-06	ETE 3	"	support basic observatory operations
25-Aug-06	ETE 4	ISOC 4 (25 Jul 06)	instrument turn on
14-Oct-06	ETE 5	"	regression test and contingencies
1-Feb-07	ETE 6	"	final ETE at launch facility

ISOC Development Schedule



ISOC Staffing Plan



Plan matches actuals through July 04

Procurement plans

- ***The large disk and CPU farms needed for pipeline storage and processing are supplied by SCS***
- ***The handful of ISOC workstations will be procured in phases but will all be in place for the final software release***
- ***Third party software is largely in place already***
  - *Final build/buy decisions on tools by November '04*
- ***No issues foreseen with H/W or purchased S/W***

ISOC Risk Status

Number	Date	Rank	Originator	Description	Mitigation
ISOC-0001	5/15/04 Retired	1	B. Craig	ISOC lacks accepted architecture and plan for software implementation.	Trade study between possible front ends to be completed by 6/15/04. Hires into s/w architecture position. Successful CDR retires risk
ISOC-0002	5/15/04 Retired	3	B. Craig	Slow response to PDR RFAs	Schedule and track RFA's weekly. 3 remain as of 8/02
ISOC-0003	5/17/04	2	B. Craig	Inadequate staffing plan for ISOC.	Draft staffing plan complete. Culp, Lemon, Steele hired, S/W developers needed in Sep/Oct
ISOC-0004	5/21/04	4	B. Craig	No facility location identified for ISOC	Long-term solution identified, short term space to be requested from SLAC management.

ISOC Risk Status (2)

Number	Date	Rank	Originator	Description	Mitigation
ISOC-0005	5/21/04	2	B. Craig	No requirements levied on I&T and Flt S/W subsystems	Mechanism in place with I&T and FSW Final disposition after joint requirements review.
ISOC-0006	5/21/04	1	B. Craig	ISOC will be unable to hold schedule due to staffing delays and unscoped work	Definition of work plan follows architecture development. Additional support supplied as requested but need to balance new hires vs transfers from other subsystems.

Issues and Concerns

- ***Frontloaded software support needed.***
  - *Need to limit hires to account for expected transfers from other subsystems.*
- ***Database architecture not as well developed as we would like***
  - *Need to deliver I&T databases soon while retaining an overall structure that makes sense for the ISOC*
- ***Requirement completeness,***
  - *risk of missing requirements, mitigation in work (DOORS and full requirement review)*
- ***Many software elements need to interoperate smoothly***
  - *Early testing reduces problem, and certainly easier than writing the code anew*

Summary

- ***Significant improvements since March peer review***
- ***Architecture in place***
  - *Based largely on existing tools*
  - *Tools mapped directly to requirements*
- ***Planning ISOC verification with Test Bed and 3 demos prior to first Ground Readiness Test***
- ***Successful CDR on August 4; ready to build, first software release is in April 2005.***